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Morphometric Multivariate Classification of *Delia antiqua* and *D. platura* from Korea (Diptera: Anthomyiidae)

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Abstract Some morphometric multivariate analyses are conducted based on the different local populations, hosts and seasonal groups both within and between *Delia antiqua* and *D. platura*, as these two pest species have been confused erroneously by many authors. The discriminant analysis shows the evidence supporting interspecific distinctions, but is insignificant in the intraspecific variations with the quantitative characters.

Key words morphometrics, multivariate analysis, discriminant analysis, Diptera, Anthomyiidae

INTRODUCTION

A morphometric classification was adopted here to find reliable quantitative characters and to clarify the interspecific and intraspecific relationships between *Delia antiqua* and *D. platura* which are serious pests of onion, garlic and spring onion, etc., in this country. As the latter pest species has been extensively confused with the former one erroneously by many authors in treating the pest management scheme in Korea, due to the superficial similarity which has led to the misidentification by entomologists lacking the special technique in genitalia examination.

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MATERIALS AND METHODS

A sample of 20 individuals for each species, either local or host populations, was taken at random throughout Korea, and some unit groups were obtained from reared culture (Table 1).

For each individual specimen, the antenna and three legs from any convenient side for handling were removed and mounted on a small rectangular piece of cardboard using a transparent glue, and wings were also mounted on a slide glass.

All the characters examined are shown in Fig. 1. All measured and meristic quantitative characters in each individual (Table 2) were obtained with the aid of microscopes, in combination with a di-

gitizer (Summasketch plus) using Autocad (v. 10) software package, interfaced with a Hercules graphic board installed in the microcomputers. All the electronic measurements are presented in 10 unit microns or 10 unit square microns.

The data were standardized, and analysed using the Wilks' lambda stepwise discriminant analysis (Norušis, 1985; SPSS Inc., 1988).

Computations were carried out through the use of the statistical package, SPSS/PC+ (v. 2.0) installed in the microcomputer (Ace 286, with Intel 80287 coprocessor). When needed, other software packages such as Lotus 123, Minitab, PE, Statgraphics, and FORTRAN programs were used.

Table 1. Data for specimens used in morphometrics (SPN: Species No., PON: Population No., HON: Host No., IND: Number of individuals, R: reared)

				IND			
SPN	PON	HON	Species	Male	Female	Host	Data
1	1	1	*D. antiqua*	20	20	garlic	Kanghwado 22. V. 89
	2			19	20	garlic	Tanyang 31. V. 89
	3			12	9	garlic	Uisong 14. IV. 89
				2	0	garlic	Uisong 26. IV. 89
				4	8	garlic	Uisong 31. V. 89
	4	2		20	20	spr. onion R	Sillyong 12. V. 89
2	5	3	*D. platura*	20	20	garlic	Kanghwado 22. V. 89
	6			20	20	garlic	Tanyang 31. V. 89
	7			20	20	garlic	Uisong 31. V. 89
	8			20	20	garlic	Sillyong 22. IV. 89
	9			20	20	garlic	Sillyong 3. VI. 89
	10			20	20	garlic	Chongju 13. V. 89
	11			20	20	garlic	Wando 12. V. 89
	12			20	20	garlic	Cheju 7. V. 89
	13	4		20	20	onion	Sillyong 22. IV. 89
	14			20	20	onion R	Taegu 3. VI. 89
	15			20	20	onion	Taegu 4. VI. 89
	16	5		20	20	spr. onion	Uijongbu 21. V. 89
	17			20	20	spr. onion R	Sillyong 12. V. 89
	18			20	20	spr. onion	Taegu 11. VI. 89
	19	6		20	20	wild	Soraksan 23. V. 89
	20			20	20	wild	Soraksan 19. VIII. 89
	21			20	20	wild	Kyeryongsan 23. V. 89
	22			20	20	wild	Ullungdo 2. VI. 89
	23			20	20	wild	P'algongsan 28. V. 89
	24			20	20	wild	Chirisan 27. V. 89
	25			20	20	wild	Kumjongsan 26. V. 89

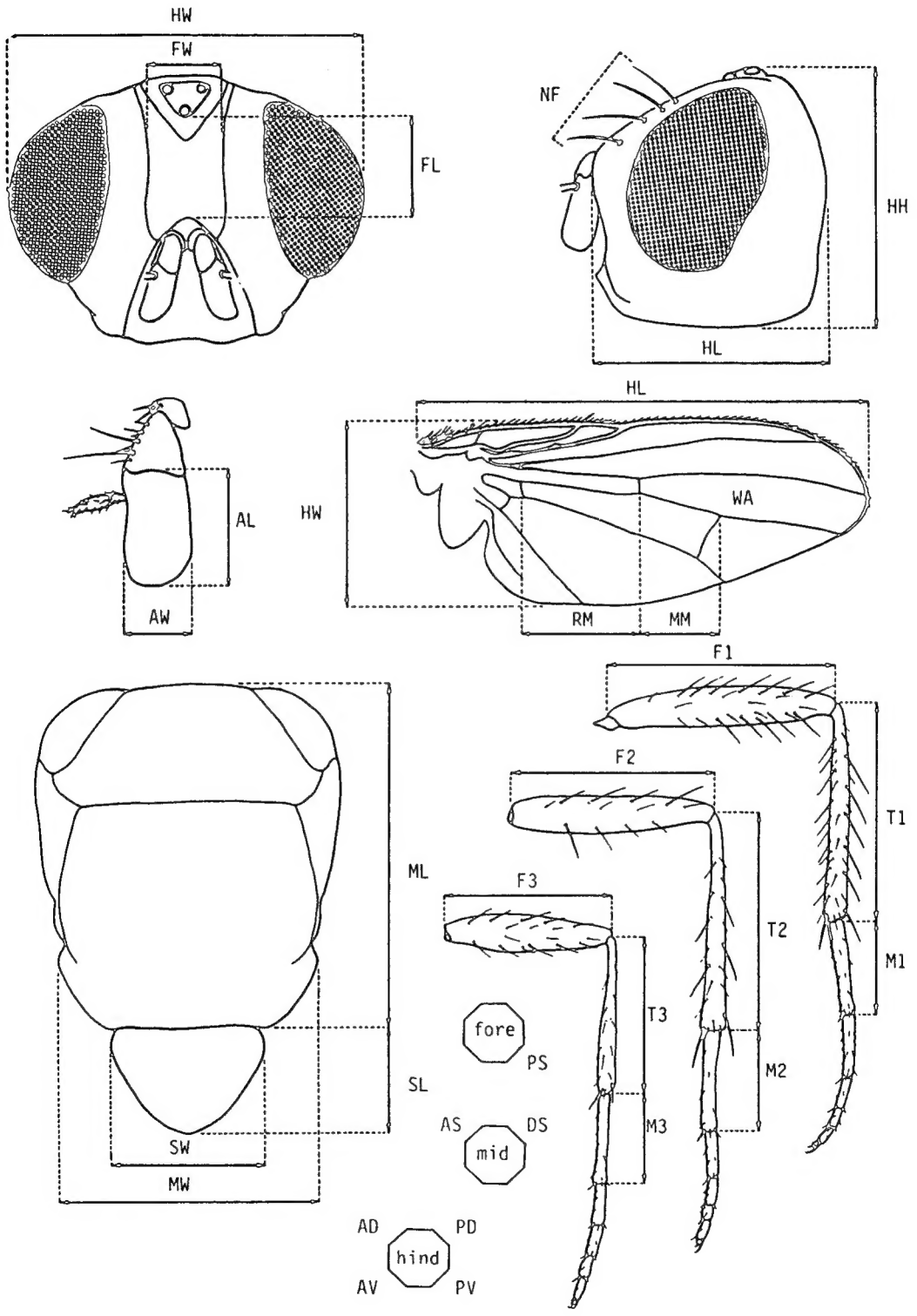

Fig. 1. Schematic drawing of the body parts used in the morphometrics (character codes as in Table 2).

Table 2. Codes for characters used in the morphometric analysis of *Delia* species (✲: selected characters in female only, +: selected characters in male only)

	No.	Code	Variable
	1	HW	Head width
	2	HL	Head length
	3	HH	Head height
	4	FW	Frons width
	5	FL	Frons length
+	6	NF	Number of frontal setae
	7	AW	3rd antennal segment width
	8	AL	3rd antennal segment length
	9	MW	Mesonotum width
	10	ML	Mesonotum length
	11	SW	Scutellum width
	12	SL	Scutellum length
	13	F1	Fore femur length
	14	T1	Fore tibia length
	15	M1	Fore metatarsus length
✲	16	PS	Number of posteroventral setae on fore tibia
	17	F2	Mid femur length
	18	T2	Mid tibia length
	19	M2	Mid metatarsus length
✲	20	AS	Number of anterodorsal setae on mid tibia
✲	21	DS	Number of posterodorsal setae on mid tibia
	22	F3	Hind femur length
	23	T3	Hind tibia length
	24	M3	Hind metatarsus length
	25	AD	Number of anterodorsal setae on hind tibia
	26	PD	Number of posterodorsal setae on hind tibia
	27	AV	Number of anteroventral setae on hind tibia
	28	PV	Number of posteroventral setae on hind tibia
	29	WW	Wing width
	30	WL	Wing length
	31	RM	Distance between anterior *m-m* and *r-m*
	32	MM	Distance between *r-m* and posterior *m-m*
	33	WA	Wing area

RESULTS

The first step of the main analysis was carried out in the different environmental conditions to reveal the intraspecific or interspecific variations of 2 *Delia* pests in both sexes.

1. Analysis for male

All 25 populations incorporating 4 groups of *Delia antiqua* and 21 groups of *D. platura*, which

were distinguished by the different localities, hosts and occurrence time, were assessed.

A total of 30 characters covering 8 from head, 4 from thorax, 13 from legs, and 5 from wing were used.

1-1. Analysis for all 25 groups regardless of species

This analysis was conducted to compare the intraspecific and interspecific variations within males only, when all 25 groups of 2 species were analyzed together.

As the result, 24 canonical discriminant functions were derived in the analysis. The first discriminant function was statistically very significant which had a variance of 80.9%, and the first 2 functions only were used for the all groups scatterplot, which revealed 2 distinct groups, *Delia antiqua* and *D. platura*. Each unit group aggregated to its known species (Fig. 2). The group centroids were plotted 3 dimensionally against function 1, 2 and 3, as they have higher variances and larger ratios between groups to within groups sum of squares, with the accumulative score of 87.97% (Fig. 3).

Smaller Wilks' lambda value and larger univariate F-ratio revealed that the number of *pv* on hind tibia was the most important character for discrimination of groups (Table 3). Some basic data for the first 10 effective characters were shown in Fig. 4.

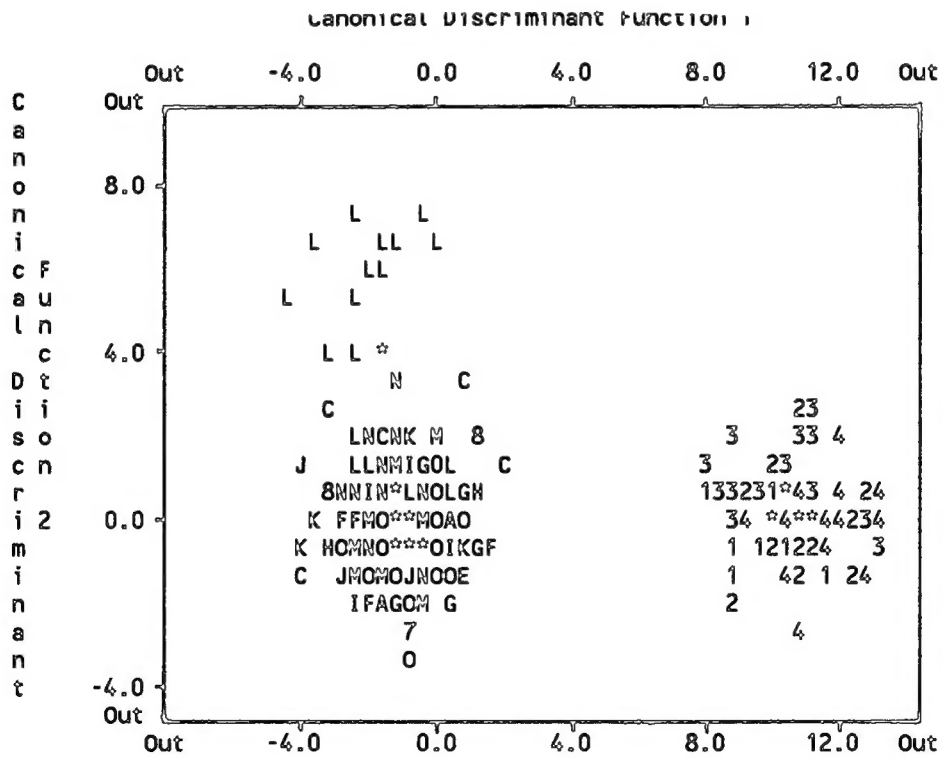

Fig. 2. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of 25 groups regardless of species in male (group numbers as in Table 1, except for 0: 10, A: 11, B: 12, C: 13, D: 14, E: 15, F: 16, G: 17, H: 18, I: 19, J: 20, K: 21, L: 22, M: 23, N: 24, O: 25).

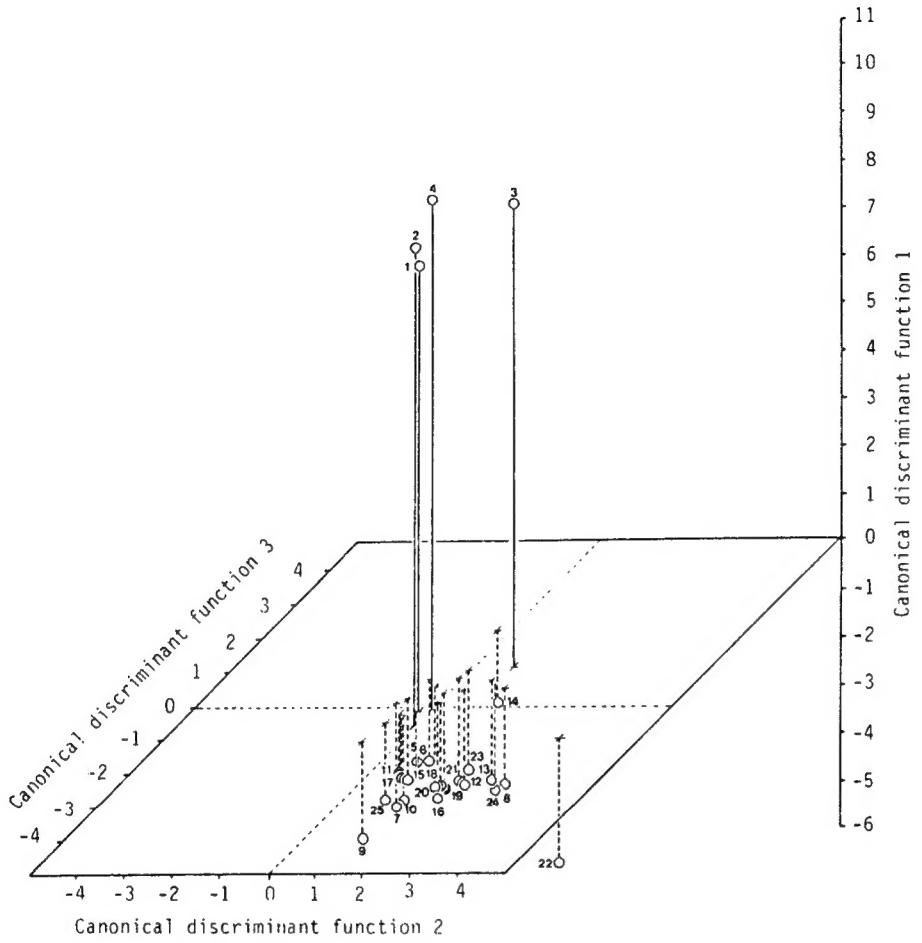

Fig. 3. 3-dimensional plot of the first 3 canonical discriminant functions by group centroids in male.

Table 3. Test for univariate equality of group means for 25 groups regardless of species in male

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.64321	10.91	.0000	F2	.51736	18.35	.0000
HL	.38432	31.51	.0000	T2	.44489	24.54	.0000
HH	.43810	25.22	.0000	M2	.60006	13.11	.0000
FW	.17587	92.16	.0000	F3	.49710	19.90	.0000
FL	.49713	19.89	.0000	T3	.58386	14.02	.0000
NF	.86256	3.134	.0000	M3	.47351	21.87	.0000
AW	.75270	6.462	.0000	AD	.76414	6.070	.0000
AL	.85419	3.357	.0000	PD	.93041	1.471	.0709
MW	.38472	31.45	.0000	AV	.89527	2.301	.0005
ML	.33790	38.54	.0000	PV	.15165	110.0	.0000
SW	.43020	26.05	.0000	WW	.48924	20.53	.0000
SL	.41468	27.76	.0000	WL	.49423	20.13	.0000
F1	.61733	12.19	.0000	RM	.53892	16.83	.0000
T1	.59655	13.30	.0000	MM	.76441	6.061	.0000
M1	.49984	19.68	.0000	WA	.34809	36.83	.0000

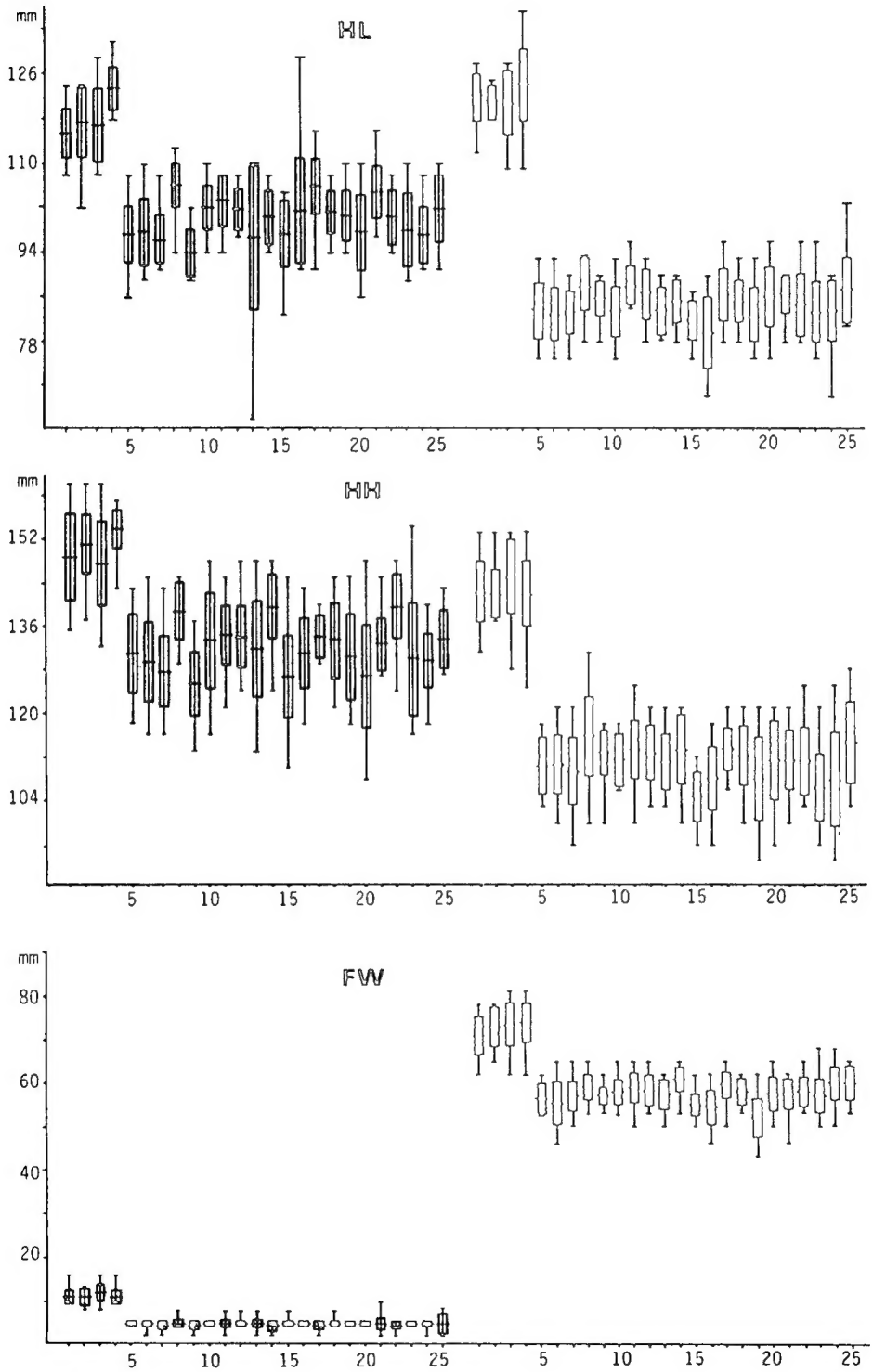

Fig. 4. Some basic data for male and female principal variables (horizontal line represents mean for each population, thick bar one standard deviation on either side of mean, thin bar total range, enclosed: female, blank: male).

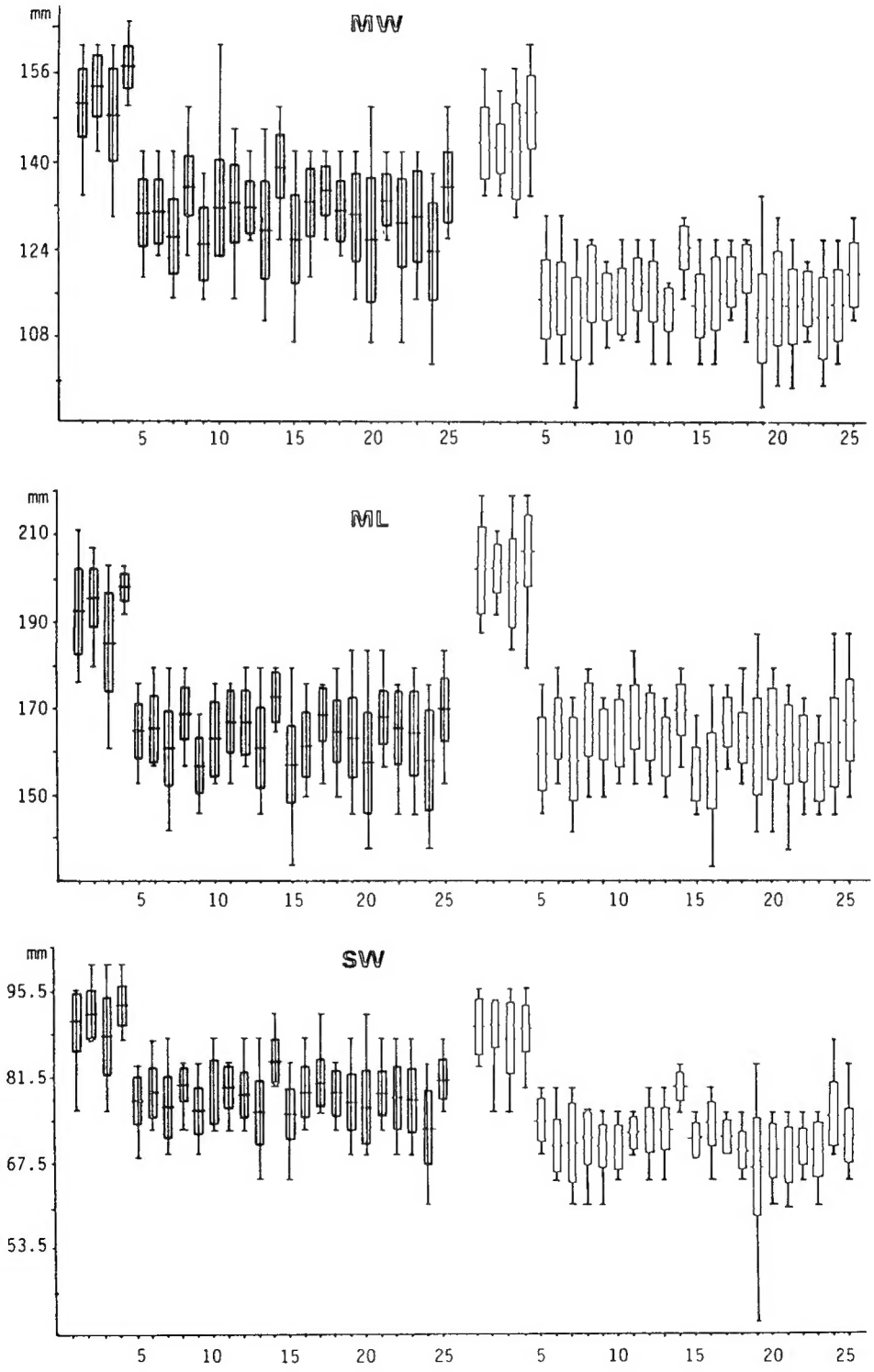

Fig. 4. Continue (2).

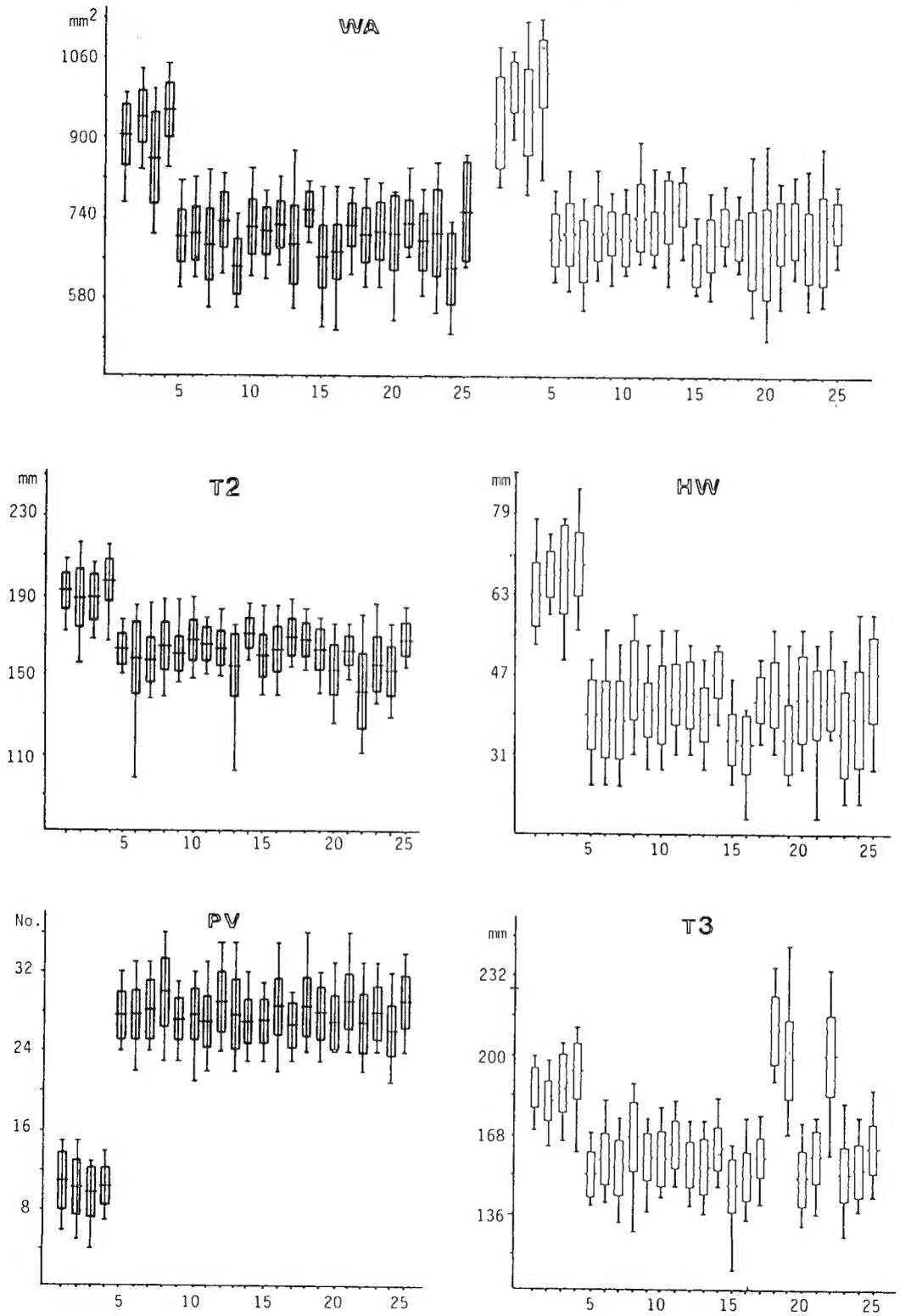

Fig. 4. Continue (3).

Table 4. Predicted group membership for 25 groups regardless of species in male

Actual Group (Locality)	No.of Cases	Predicted Group Membership																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1 *antiqua*	20	13	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Kanghwado)		65.0%	20.0%	15.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
2 *antiqua*	19	4	11	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Tanyang)		21.1%	57.9%	.0%	21.1%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
3 *antiqua*	18	2	0	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Uisong)		11.1%	.0%	83.3%	5.6%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
4 *antiqua*	20	0	4	2	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Sillyong)		.0%	20.0%	10.0%	70.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
5 *platura*	20	0	0	0	0	9	0	0	0	1	0	0	1	0	2	1	0	1	0	1	0	1	0	1	1	1
(Kanghwado)		.0%	.0%	.0%	.0%	45.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	10.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	5.0%	5.0%
6 *platura*	20	0	0	0	0	1	12	1	0	0	0	0	1	1	0	0	1	0	0	1	1	1	0	0	0	0
(Tanyang)		.0%	.0%	.0%	.0%	5.0%	60.0%	5.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	5.0%	5.0%	.0%	.0%	.0%	.0%
7 *platura*	20	0	0	0	0	1	0	14	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0
(Uisong)		.0%	.0%	.0%	.0%	5.0%	.0%	70.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%
8 *platura*	20	0	0	0	0	0	0	0	14	0	0	0	2	1	1	0	1	0	0	0	0	0	0	0	1	0
(Sillyong)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	70.0%	.0%	.0%	.0%	10.0%	5.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%
9 *platura*	20	0	0	0	0	1	0	0	0	12	1	0	0	0	1	2	1	1	0	0	0	0	0	0	0	1
(Sillyong)		.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	60.0%	5.0%	.0%	.0%	.0%	5.0%	10.0%	5.0%	5.0%	.0%	.05	.0%	.0%	.0%	.0%	.05	5.0%
10 *platura*	20	0	0	0	0	1	1	0	0	0	12	1	1	0	0	1	0	0	0	1	0	1	0	0	0	1
(Chongju)		.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	60.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	5.0%
11 *platura*	20	0	0	0	0	0	0	0	0	1	1	12	0	0	0	1	0	2	0	1	0	1	0	0	1	0
(Wando)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	60.0%	.0%	.0%	.0%	5.0%	.0%	10.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	5.0%	.0%
12 *platura*	20	0	0	0	0	0	1	0	2	0	0	2	7	0	0	1	0	0	1	3	0	0	0	1	1	1
(Cheju)		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	10.0%	.0%	.0%	10.0%	35.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	15.0%	.0%	.0%	.0%	5.0%	5.0%	5.0%
13 *platura*	20	0	0	0	0	0	0	0	0	0	0	0	2	9	0	1	0	0	0	2	0	1	1	1	1	2
(Sillyong)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%	45.0%	.0%	5.0%	.0%	.0%	.0%	10.0%	.0%	5.0%	5.0%	5.0%	5.0%	10.0%
14 *platura*	20	0	0	0	0	2	1	1	0	0	1	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0
(Taegu)		.0%	.0%	.0%	.0%	10.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	.0%	75.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
15 *platura*	20	0	0	0	0	1	0	10	2	1	2	1	0	1	9	0	0	0	0	1	0	0	0	1	0	
(Taegu)		.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	10.0%	5.0%	10.0%	5.0%	.0%	5.0%	45.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	5.0%	.0%
16 *platura*	20	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	9	3	0	1	0	0	0	2	1	0
(Cijongbu)		.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	45.0%	15.0%	.0%	5.0%	.0%	.0%	.0%	10.0%	5.0%	.0%
17 *platura*	20	0	0	0	0	0	0	0	1	1	0	2	0	0	2	0	0	12	0	2	0	0	0	0	0	0
(Sillyong)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	10.0%	.0%	.0%	10.0%	.0%	.0%	60.0%	.0%	10.0%	.0%	.0%	.0%	.0%	.0%	.0%
18 *platura*	20	0	0	0	0	1	0	1	0	0	0	0	0	1	1	1	1	0	12	0	1	0	0	0	0	1
(Taegu)		.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	5.0%	5.0%	.0%	60.%	.0%	5.0%	.0%	.0%	.0%	.0%	5.0%
19 *platura*	20	0	0	0	0	2	0	0	1	0	2	0	2	2	0	2	1	0	1	2	0	2	0	1	1	1
(Soraksan)		.0%	.0%	.0%	.0%	10.0%	.0%	.0%	5.0%	.0%	10.0%	.0%	10.0%	10.0%	.0%	10.0%	5.0%	.0%	5.0%	10.0%	.0%	10.0%	.0%	5.0%	5.0%	5.0%
20 *platura*	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	12	0	0	3	1	1
(Soraksan)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	5.0%	.0%	60.0%	.0%	.0%	15.0%	5.0%	5.0%
21 *platura*	20	0	0	0	0	1	0	0	0	0	0	3	1	0	0	1	0	1	1	2	0	9	0	0	0	1
(Kyerongsan)		.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	15.0%	5.0%	.0%	.0%	5.0%	.0%	5.0%	5.0%	10.0%	.0%	45.0%	.0%	.0%	.0%	5.0%
22 *platura*	20	0	0	0	0	1	0	0	1	0	0	0	0	2	1	0	0	0	0	1	0	0	13	0	1	0
(Ullungdo)		.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	10.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	65.0%	.0%	5.0%
23 *platura*	20	0	0	0	0	0	1	0	0	1	0	0	2	2	0	0	0	1	0	0	1	2	1	9	0	0
(P'algongsan)		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	10.0%	10.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	10.0%	5.0%	45.0%	.0%	.0%
24 *platura*	20	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	3	0	1	1	0	12	0
(Chirisan)		.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	15.0%	.0%	5.0%	5.0%	.0%	60.0%	.0%
25 *platura*	20	0	0	0	0	0	2	0	0	2	1	1	1	0	0	0	0	1	0	1	0	1	0	0	0	10
(Kumjongsan)		.0%	.0%	.0%	.0%	.0%	10.0%	.0%	.0%	10.0%	5.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	50.0%

Percent of "grouped" cases correctly classified : 55.94%

Tests of significances between pairs of group centroids using the F-statistics were carried out after step 29. Populations 5 (from Kanghwado) and 19 (from Soraksan) of *Delia platura* did not differ significantly from most other populations of *D. platura* respectively ($P>0.001$).

The predicted group membership gave an average of 55.94% of individuals classified in their known group (Table 4).

In most populations, the intraspecific morphological variation was less recognized.

1-2. Analysis for interspecific level

To reveal any morphological segregation between *Delia antiqua* and *D. platura*, 2 discriminant analyses using all characters including meristic, and measured characters only, were made respectively.

1-2-1. Analysis using all characters

To evaluate morphological distinction between 2 species, all intraspecific groups were merged into their respective species.

The discrimination achieved between *Delia antiqua* and *D. platura* was shown by the stacked histogram which revealed 2 morphometrically distinct groups (Fig. 5).

The key characters for discrimination between the 2 species were the number of *pv* on hind tibia and the frons width (Table 5).

The F-statistics between the 2 species group centroids after step 22 was highly significant ($P<0.001$).

Among 23 characters entered into the analysis, the number of *pv* setae on hind tibia was first entered into computation to discriminate between 2 species, whereas the number of *pd* setae of hind tibia was lastly entered.

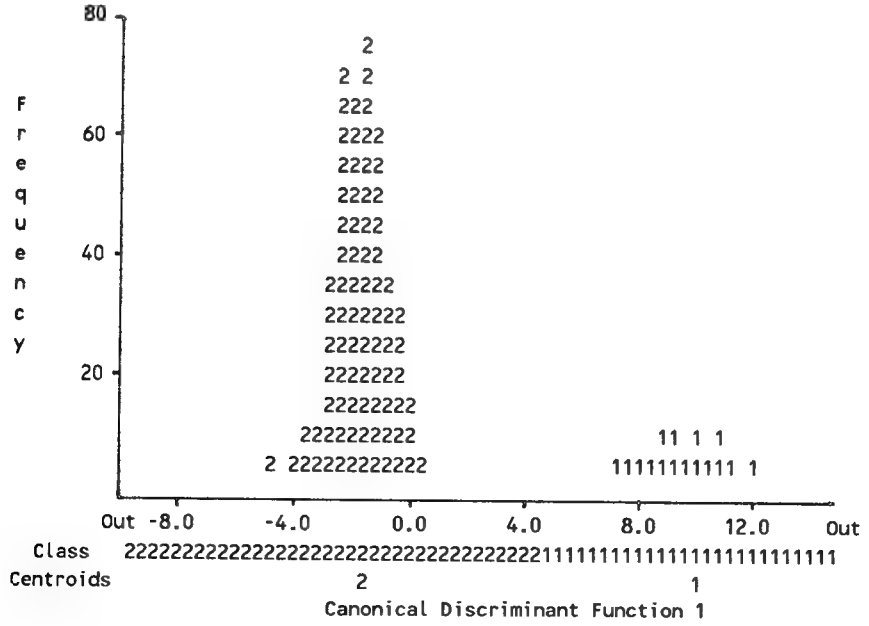

Fig. 5. All-groups stacked histogram of canonical discriminant function 1 against function 2 for morphometric analysis of species using all characters in male (group numbers as in Table 1).

Table 5. Tests for univariate equality of group means for different species using all characters in male

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.85230	85.78	.0000	F2	.65186	264.4	.0000
HL	.50283	489.4	.0000	T2	.58096	357.0	.0000
HH	.57451	366.6	.0000	M2	.68013	232.8	.0000
FW	.18873	2128.	.0000	F3	.66403	250.4	.0000
FL	.64411	273.5	.0000	T3	.69411	218.1	.0000
NF	.91046	48.68	.0000	M3	.62721	294.2	.0000
AM	.86920	74.49	.0000	AD	.82334	106.2	.0000
AL	.98861	5.704	.0173	PD	.99963	.1820	.6699
MW	.49830	498.4	.0000	AV	.99751	1.238	.2664
ML	.43756	636.3	.0000	PV	.16671	2474.	.0000
SW	.53905	423.3	.0000	WW	.60893	317.9	.0000
SL	.55271	400.6	.0000	WL	.63742	281.6	.0000
F1	.77848	140.9	.0000	RM	.65544	260.2	.0000
T1	.76450	152.5	.0000	MM	.91647	45.12	.0000
M1	.59173	341.5	.0000	WA	.44523	616.8	.0000

Table 6. Predicted group membership for different species using all characters in male

Actual group (species)	No.of Cases	Predicted Group Membership 1	2
1 *antiqua*	77	77	0
		100.0%	.0%
2 *platura*	420	0	420
		.0%	100.0%

Precent of "grouped" cases correctly classified : 100.00%

In the classification results, each species group revealed 100% successful classification (Table 6). This demonstrates that *Delia antiqua* are *D. platura* are distinct species morphologically.

1-2-2. Analysis excluding meristic characters

The present analysis was conducted to estimate the discriminant abilities of each character excluding 5 meristic characters for distinction between 2 species.

As in the previous analysis, the stacked histogram represented 2 morphometrically distinct groups (Fig. 6).

When 5 meristic characters were excluded, the width of frons, the length of mesonotum, and the area of wing were posed as very powerful discriminator (Table 7).

The F-statistic between the 2 species groups after step 18 was very significant ($P<0.001$).

In the course of the analysis, the width of frons was first entered into step, whereas the length of mid tibia was lastly entered.

As in the case of all character analysis, every species group successfully aggregated 2 morphologically distinct groups, known as *antiqua* and *platura* (Table 8).

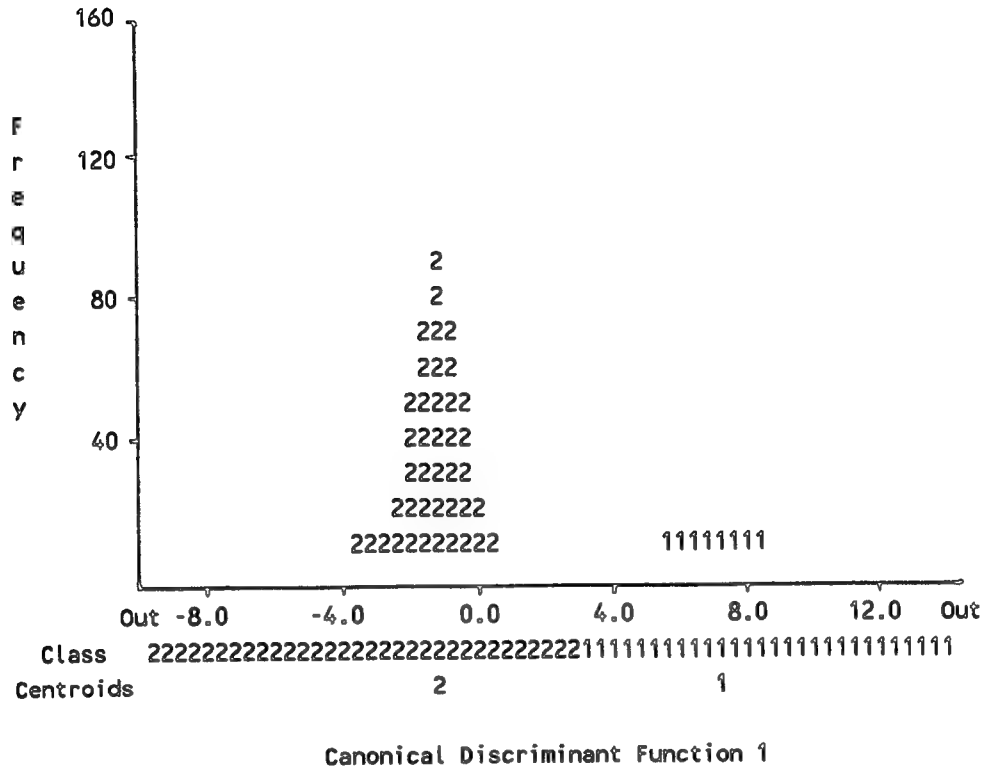

Fig. 6. All-groups stacked histogram of canonical discriminant function 1 against function 2 for morphometric analysis of species using measured characters only in male (group numbers as in Table 1).

Table 7. Tests for univariate equality of group means for different species using measured characters only in male

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.85230	85.78	.0000	M1	.59173	341.5	.0000
HL	.50283	489.4	.0000	F2	.65186	264.4	.0000
HH	.57451	366.6	.0000	T2	.58096	357.0	.0000
FW	.18873	2128.	.0000	M2	.68013	232.8	.0000
FL	.64411	273.5	.0000	F3	.66403	250.4	.0000
AW	.86920	74.49	.0000	T3	.69411	218.1	.0000
AL	.98861	5.704	.0173	M3	.62721	294.2	.0000
MW	.49830	498.4	.0000	WW	.60893	317.9	.0000
ML	.43756	636.3	.0000	WL	.63742	281.6	.0000
SW	.53905	423.3	.0000	RM	.65544	260.2	.0000
SL	.55271	400.6	.0000	MM	.91647	45.12	.0000
F1	.77848	140.9	.0000	WA	.44523	616.8	.0000
T1	.76450	152.5	.0000				

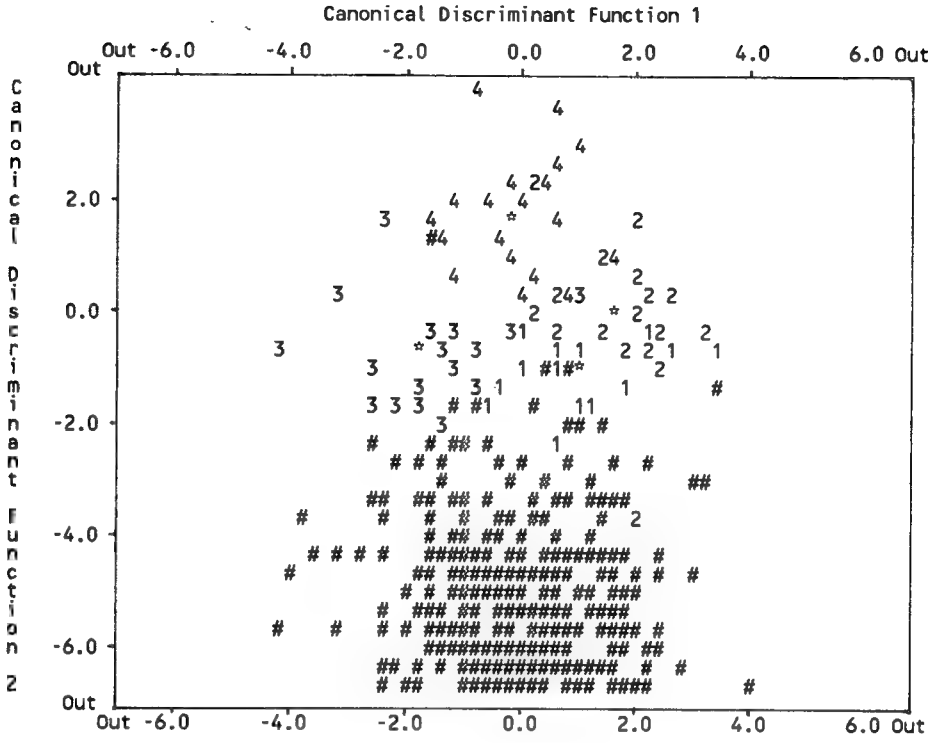

Fig. 7. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of different populations of *Delia antiqua* in male (group numbers as in Table 1, except for, # : ungrouped cases).

1-3. Analysis for intraspecific level

In this analysis, the intraspecific variations in different localities and hosts within *Delia antiqua* and *D. platura* were assessed respectively.

1-3-1. Analysis for *Delia antiqua*

To find the intraspecific morphological variations within *Delia antiqua* according to different localities and hosts, 4 different local populations with 2 different host populations were compared.

1-3-1-1. Analysis of different populations

To demonstrate the intraspecific variational ranges in different localities, 4 different populations were compared.

Table 8. Predicted group membership for different species using measured characters only in male

Actual Group (species)	No.of Cases	Predicted Group Membership 1	2
1 *antiqua*	77	77	0
		100.0%	.0%
2 *platura*	420	0	420
		.0%	100.0%

Percent of "grouped" cases correctly classified : 100.00%

Table 9. Tests for univariate equality of group means for different populations of *Delia antiqua* in male

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.87761	3.393	.0223	F2	.91716	2.198	.0955
HL	.74934	8.140	.0001	T2	.91418	2.284	.0860
HH	.87235	3.561	.0183	M2	.91709	2.200	.0953
FW	.95644	1.108	.3514	F3	.73048	8.978	.0000
FL	.90904	2.435	.0716	T3	.93324	1.741	1.662
NF	.96021	1.008	.3941	M3	.63905	13.74	.0000
AW	.86183	3.901	.0121	AD	.86747	3.718	.0151
Al	.91652	2.216	.0934	PD	.98667	.3287	.8046
MW	.77257	7.163	.0003	AV	.90936	2.426	.0724
ML	.75279	7.991	.0001	PV	.97620	.5933	.6214
SW	.86292	3.866	.0127	WW	.78180	6.792	.0004
SL	.57415	18.05	.0000	WL	.71367	9.763	.0000
F1	.96011	1.011	.3929	RM	.85487	4.131	.0092
T1	.90746	2.482	.0677	MM	.77985	6.869	.0004
M1	.85742	4.046	.0102	WA	.75293	7.985	.0001

As the result, 3 discriminant functions were derived. The first 2 functions were statistically very significant ($P<0.001$) with an accumulative variance of 89.67%, and were used in the all groups scatterplot (Fig. 7).

The most powerful discriminator was the length of scutellum, but the number of *pd* on hind tibia was the least (Table 9).

Tests of significance between pairs of group centroids using the F-statistics were carried out after step 16. Most are significantly different ($P<0.001$) except populations 1 and 2 which are not significantly different ($P<0.01$).

As for the predicted group membership, group 2 had the lowest correct assignment at 63.2%, with 15.8% predicted as group 1 (from Kanghwado), and 21.1% for group 4 (from Sillyong). Over-

Table 10. Predicted group membership for different populations of *Delia antiqua* in male

Actual Group (Locality)	No.of Cases	Predicted Group Membership 1	2	3	4
1 Kanghwado	20	15	4	1	0
		75.0%	20.0%	5.0%	.0%
2 Tanyang	19	3	12	0	4
		15.8%	63.2%	.0%	21.1%
3 Uisong	18	1	1	15	1
		5.6%	5.6%	83.3%	5.6%
4 Sillyong	20	0	2	0	18
		.0%	10.0%	.0%	90.0%
Ungrouped	420	276	6	137	1
Cases		65.7%	1.4%	32.6%	.2%

Percent of "grouped" cases correctly classified : 77.92%

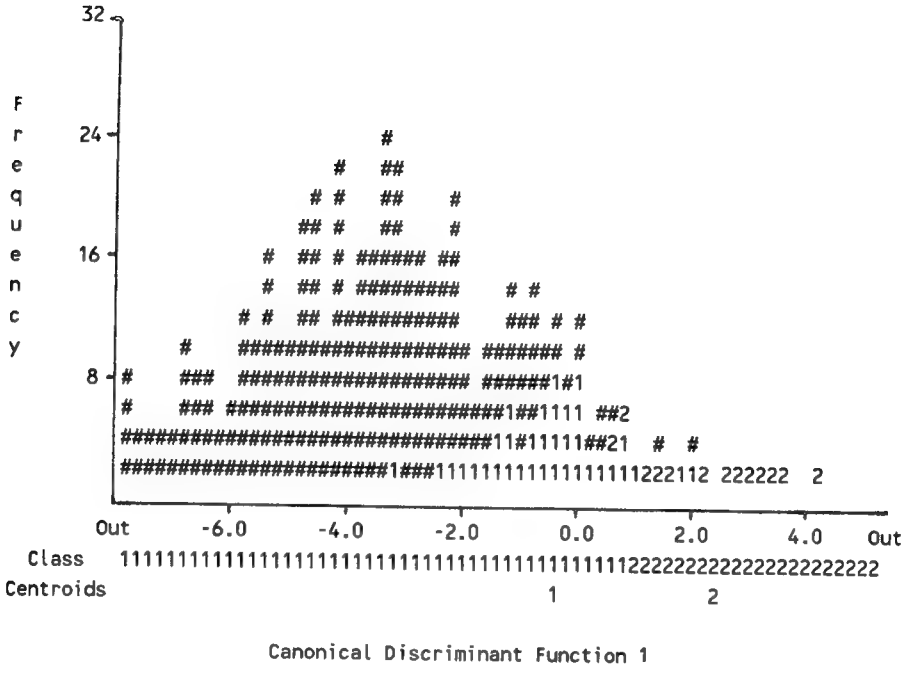

Fig. 8. All-groups stacked histogram of canonical discriminant function 1 against function 2 for morphometric analysis of different host populations of *Delia antiqua* in male (grouped numbrs as in Table 1, except for, # : ungrouped cases).

Table 11. Tests for univariate equality of group means by different host populations of *Delia antiqua* in male

Variable	Wilks' Lambda	F	Sign.	Variable	Willks' Lambda	F	Sign.
HW	.91099	7.328	.0084	F2	.96900	2.400	.1256
HL	.76386	23.19	.0000	T2	.92646	5.953	.0171
HH	.90710	7.681	.0070	M2	.96121	3.027	.0860
FW	.99819	.1358	.7135	F3	.75642	24.15	.0000
FL	.91017	7.402	.0081	T3	.93330	5.360	.0233
NF	.96620	2.624	.1095	M3	.71492	29.91	.0000
AW	.96958	2.353	.1292	AD	.89909	8.418	.0049
AL	.99233	.5795	.4489	PD	1.00000	.31E-04	.9956
MW	.84564	13.69	.0004	AV	.98881	.8490	.3598
ML	.90271	8.083	.0058	PV	.99999	.43E-03	.9834
SW	.92935	5.702	.0195	WW	.91214	7.224	.0089
SL	.94643	4.245	.0428	WL	.89484	8.814	0040
F1	.97849	1.649	.2031	RM	.88369	9.817	.0024
T1	.92199	6.346	.0139	MM	1.00000	.26E-03	.9871
M1	.88481	9.764	.0025	WA	.89984	8.348	.0050

all, 77.92% of all individuals were correctly classified to their own population (Table 10). The intraspecific morphometrical distinction, as a rule, was less significant though some groups might be recognized.

1-3-1-2. Analysis for different host

This analysis was conducted to demonstrate the intraspecific variations by 2 different host populations collected from garlics and spring onions respectively (Table 1).

The discrimination between the 2 host groups was shown by the stacked histogram which revealed a slight overlap between the groups (Figure 8).

In the U-statistics and univariate F-ratio (Table 11), most characters used were not significant for discrimination of groups ($P>0.01$), but the length of head and the length of hind metatarsus were very effective ($P<0.001$).

After step 16, the F-statistic and significance between the 2 groups centroids were highly significant ($P<0.001$).

Among 16 characters entered into the analysis for intraspecific discrimination, the first entered character was the length of hind metatarsus, but the numbers of *pd* on hind tibia was lastly entered.

The predicted group membership gave an average of 92.21% of individuals classified into their known group, and higher than the previous analysis (Table 12).

Therefore, morphological differences of the species were more evident by hosts than by distributional areas.

Table 12. Predicted group membership by different host populations of *Delia antiqua* in male

Actual Group (Host)	No. of Cases	Predicted Group Membership 1	2
1 Gralic	57	54	3
		94.7%	5.3%
20 Spring Onion	2	3	17
		15.0%	85.0%
Ungrouped	420	415	5
Cases		98.8%	1.2%

Percent of "grouped" cases correctly classified: 92.21%

1-3-2. Analysis for *Delia platura*

To estimate the intraspecific morphological variations within *Delia platura* according to different localities, hosts or occurrence times, 21 different local populations or 4 different host populations were compared here.

1-3-2-1. Analysis of different populations

To find any intraspecific variations in different localities or occurrence times, 21 different populations, hosts or occurrence times, 21 different populations were used (Table 1).

As the result, 20 discriminant functions were derived, and the first 8 functions were statistically significant ($P<0.001$) with an accumulative variance of 81.97%. The first 2 functions were used in the all groups scatterplot in which group 22 (from Üllungdo) were separated from the others (Fig. 9).

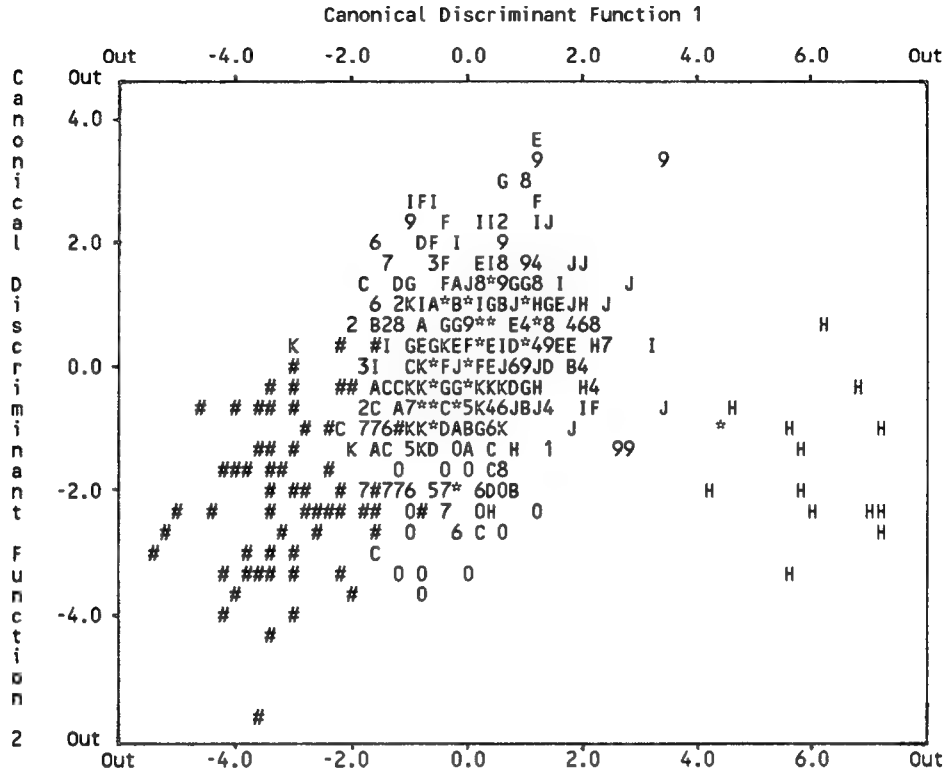

Fig. 9. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of different populations of *Delia platura* in male (group numbers indicated as, 1: 5, 2: 6, 3: 7, 4: 8, 5: 9, 6: 10, 7: 11, 8: 12, 9: 13, 0: 14, A: 15, B: 16, C: 17, D: 18, E: 19, F: 20, G: 21, H: 22, I: 23, J: 24, K: 24 #: ungrouped cases).

Table 13. Tests for univariate equality of group means for different populations of *Delia platura* in male

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.74010	7.006	.0000	T2	.74483	6.835	.0000
HL	.76659	6.074	.0000	M2	.87790	2.775	.0001
HH	.74774	6.730	.0000	F3	.75122	6.607	.0000
FW	.91164	1.934	.0095	T3	.83065	4.067	.0000
FL	.74497	6.829	.0000	M3	.78643	5.418	.0000
NF	.94600	1.139	.3065	AD	.93325	1.427	.1053
AW	.86678	3.066	.0000	PD	.91535	1.845	.0151
AL	.85696	3.330	.0000	AV	.89538	2.331	.0011
MW	.77201	5.892	.0000	PV	.89997	2.217	.0021
ML	.77594	5.761	.0000	WW	.80687	4.775	.0000
SW	.78647	5.416	.0000	WL	.78367	5.507	.0000
SL	.79543	5.131	.0000	RM	.81602	4.498	.0000
F1	.77898	5.660	.0000	MM	.85047	3.508	.0000
T1	.76711	6.057	.0000	WA	.78825	5.359	.0000

In most characters, the discriminant abilities for groups were more or less similar (Table 13). Among them, the width of head was a better discriminator, and the discriminant abilities of all the meristic characters were less than those of measured characters.

Tests of significance between pairs of group centroids using the F-statistics were carried out after step 29. Many were significantly different ($P<0.001$), but some pairs of groups were not.

Among 29 characters entered into the analysis, the width of head was first entered into the computation for intraspecific discrimination, whereas the number of *ad* setae on hind tibia was lastly entered.

The predicted group membership gave an average of 54.29% of individuals classified in their known group (Table 14). Group 19 (from Soraksan) had the lowest correct assignment at 20%. Therefore, the intraspecific variation is proved less to be recognized.

1-3-2-2. Analysis for different host

To evaluate the intraspecific morphological variations within *Delia platura* for different hosts, 4 different host populations were analyzed (Table 1).

As the result, 3 discriminant functions were derived. The first 2 functions were statistically significant with an accumulative variance of 81.64%, and were used for the all groups scatterplot (Fig. 10).

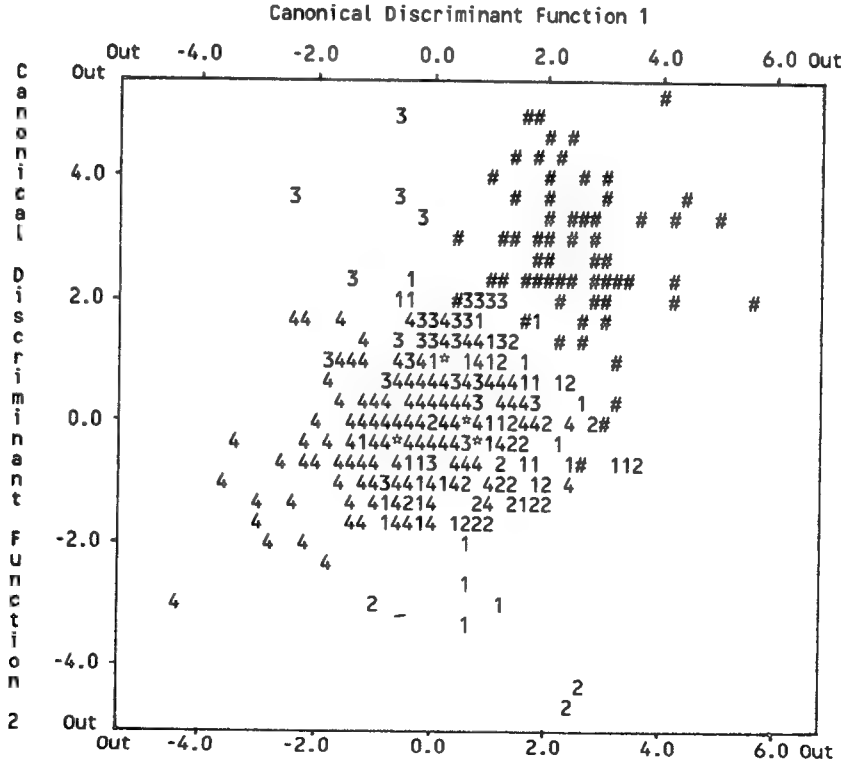

Fig. 10. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of different host populations of *Delia platura* in male (group numbers indicated as, 1 : 3, 2 : 4, 3 : 5, 4 : 6, # : ungrouped cases).

Table 14. Predicted group membership for different populations of *Delia platura* in male

Actual Group (Locality)	No.of Cases	Predicted Group Membership																				
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
5 Kanghwado	20	9	0	0	0	1	0	0	1	0	2	1	0	1	0	2	0	0	0	1	1	1
		45.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	10.0%	5.0%	.0%	5.0%	.0%	10.0%	.0%	.0%	.0%	5.0%	5.0%	5.0%
6 Tanyang	20	1	13	0	0	1	0	0	1	1	0	0	1	0	0	1	1	0	0	0	0	0
		5.0%	65.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%
7 Ŭisŏng	20	1	0	12	0	0	0	2	1	0	0	0	1	0	1	0	0	0	0	0	1	1
		5.0%	.0%	60.0%	.0%	.0%	.0%	10.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%
8 Sillyŏng	20	0	0	0	13	0	0	0	2	1	2	0	1	0	0	0	0	0	0	0	1	0
		.0%	.0%	.0%	65.0%	.0%	.0%	.0%	10.0%	5.0%	10.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%
9 Sillyŏng	20	1	0	0	0	12	1	0	0	0	0	1	2	1	0	1	0	0	0	0	0	1
		5.0%	.0%	.0%	.0%	60.0%	5.0%	.0%	.0%	.0%	.0%	5.0%	10.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%
10 Chŏngju	20	1	1	0	0	0	11	1	1	0	0	1	0	0	0	2	0	1	0	0	0	1
		5.0%	5.0%	.0%	.0%	.0%	55.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	.0%	10.0%	.0%	5.0%	.0%	.0%	.0%	5.0%
11 Wando	20	0	0	0	0	1	1	12	0	0	1	1	0	2	0	1	0	1	0	0	0	0
		.0%	.0%	.0%	.0%	5.0%	5.0%	60.0%	.0%	.0%	5.0%	5.0%	.0%	10.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%
12 Cheju	20	0	1	0	2	0	0	2	7	0	0	1	0	0	1	3	0	0	0	1	0	2
		.0%	5.0%	.0%	10.0%	.0%	.0%	10.0%	35.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	15.0%	.0%	.0%	.0%	5.0%	.0%	10.0%
13 Sillyŏng	20	0	0	1	0	0	0	0	0	12	0	1	0	0	0	2	0	1	0	0	1	2
		.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	60.0%	.0%	5.0%	.0%	.0%	.0%	10.0%	.0%	5.0%	.0%	.0%	5.0%	10.0%
14 Taegu	20	2	1	1	0	0	2	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0
		10.0%	5.0%	5.0%	.0%	.0%	10.0%	.0%	.0%	.0%	70.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
15 Taegu	20	1	0	1	0	2	2	1	1	0	1	8	0	1	1	0	1	0	0	0	0	0
		5.0%	.0%	5.0%	.0%	10.0%	10.0%	5.0%	5.0%	.0%	5.0%	40.0%	.0%	5.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%
16 Ŭijŏngbu	20	1	0	1	1	1	0	0	0	0	0	0	10	1	0	1	0	1	0	2	1	0
		5.0%	.0%	5.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	50.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	10.0%	5.0%	.0%
17 Sillyŏng	20	0	0	1	1	1	0	2	0	0	1	0	0	13	0	1	0	0	0	0	0	0
		.0%	.0%	5.0%	5.0%	5.0%	.0%	10.0%	.0%	.0%	5.0%	.0%	.0%	65.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%
18 Taegu	20	0	1	1	0	0	0	0	0	1	1	1	1	0	12	0	1	0	0	0	0	1
		.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	5.0%	5.0%	.0%	60.0%	.0%	5.0%	.0%	.0%	.0%	.0%	5.0%
19 Sŏraksan	20	2	0	0	1	0	3	0	1	2	0	1	1	1	1	4	0	1	0	0	1	1
		10.0%	.0%	.0%	5.0%	.0%	15.0%	.0%	5.0%	10.0%	.0%	5.0%	5.0%	5.0%	5.0%	20.0%	.0%	5.0%	.0%	.0%	5.0%	5.0%
20 Sŏraksan	20	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	11	0	0	3	1	1
		.0%	.0%	.0%	.0%	.0%.	0%	.0%	.0%	.0%	.0%	10.0%	.0%	5.0%	5.0%	.0%	55.0%	.0%	.0%	15.0%	5.0%	5.0%
21 Kyerongsan	20	2	0	0	0	0	0	2	1	0	0	1	1	0	0	2	0	10	0	0	0	1
		10.0%	.0%	.0%	.0%	.0%	.0%	10.0%	5.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	10.0%	.0%	50.0%	.0%	.0%	.0%	5.0%
22 Ŭllŭngdo	20	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	13	0	3	0
		5.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	65.0%	.0%	15.0%	.0%
23 P'algongsan	20	0	1	0	0	1	0	0	2	2	0	0	0	1	0	0	0	2	1	10	0	0
		.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	10.0%	10.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	10.0%	5.0%	50.0%	.0%	.0%
24 Chirisan	20	1	0	1	0	0	0	0	0	0	0	0	0	0	1	3	0	1	1	0	12	0
		5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	15.0%	.0%	5.0%	5.0%	.0%	60.0%	.0%
25 Kŭmjŏngsan	20	0	2	0	0	2	2	1	0	0	0	0	0	1	0	1	0	1	0	0	0	10
		.0%	10.0%	.0%	.0%	10.0%	10.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	50.0%
Ungrouped Cases	77	0	0	0	0	0	0	63	0	0	0	0	0	14	0	0	0	0	0	0	0	0
		.0%	.0%	.0%	.0%	.0%	.0%	81.8%	.0%	.0%	.0%	.0%	.0%	18.2%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%

Percent of "grouped" cases correctly classified: 54.29%

As in the previous analysis, most discriminators derived were insignificant (P)0.001), but only the following 4 characters were very effective : the lengths of mid femur, mid tibia, hind femur, and hind metatarsus (Table 15).

After step 18, the F-statistics and significances between pairs of groups were highly significant (P(0.001).

Among 18 characters entered into the analysis, the length of mid tibia was first entered into computation for the intraspecific discrimination, but the width of wing was lastly entered.

In the classification result, the predicted group membership was slightly lower than that of different populations (Table 16). The 50.7% of individuals were correctly classified to their known group. Thus as in the previous analysis, the interspecific variation for hosts was also less recognized.

Table 15. Tests for univariate equality of group means by different host populations of *Delia platura* in male

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.99501	.6959	.5550	F2	.95377	6.722	.0002
HL	.96300	5.328	.0013	T2	.93214	10.10	.0000
HH	.99679	.4467	.7198	M2	.98380	2.284	.0784
FW	.99942	.81E-01	.9703	F3	.95444	6.620	.0002
FL	.99027	1.362	.2540	T3	.97297	3.852	.0097
NF	.99524	.6638	.5747	M3	.94035	8.796	.0000
AW	.99511	.6808	.5642	AD	.99157	1.180	.3172
AL	.99569	.5999	.6154	PD	.99734	.3697	.7749
MW	.98293	2.408	.0666	AV	99221	1.088	.3539
ML	.99797	.2815	.8388	PV	.99315	.9559	.4135
SW	.98563	2.021	.1103	WW	.99882	.1638	.9207
SL	.98140	2.628	.0499	WL	.99611	.5422	.6537
F1	.97885	2.996	.0306	RM	.98675	1.862	1354
T1	.99840	.2221	.8811	MM	.98621	1.938	1.227
M1	.99198	1.121	.3401	WA	.99845	.2156	.8856

Table 16. Predicted group membership by different host populations of *Delia platura* in male

Actual Group (Host)	No.of Cases	Predicted Group Membership 3	4	5	6
3 Garlic	160	72	38	25	25
		45.0%	23.8%	15.6%	15.6%
4 Onion	60	11	31	10	8
		18.3%	51.7%	16.7%	13.3%
5 Spring Onion	60	10	10	36	4
		16.7%	16.7%	60.0%	6.7%
6 Wild	140	24	20	22	74
		17.1%	14.3%	15.7%	52.9%
Ungrouped	77	13	2	61	1
Cases		16.9%	2.6%	79.2%	1.3%

Percent of "grouped" cases correctly classified: 50.71%

2. Analysis for female

All items analyzed in the females are the same as those in the males. A sum of 32 characters covering 7 from head, 4 from thorax, 16 from legs, and 5 from wing were used.

2-1. Analysis for all 25 groups regardless of species

Among 24 discriminant functions derived in the analysis, the first one was very significant with a variance of 68.70%. Only functions 1 and 2 with an accumulative variance of 86.47% were used in the all groups scatterplot which revealed 2 distinct aggregative groups (Fig. 11). The group centroids were plotted 3 dimensionally against function 1, 2 and 3 (Fig. 12).

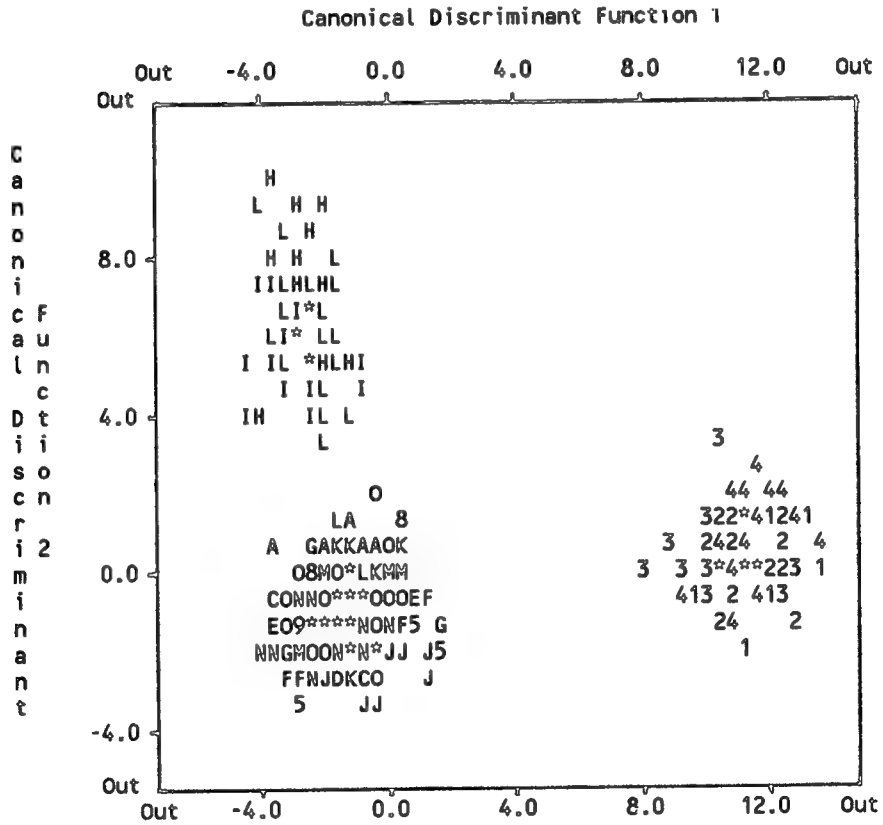

Fig. 11. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of 25 groups regardless of species in female (group numbers as in Table 1, except for, 0: 10, A: 11, B: 12, C: 13, D: 14, E: 15, F: 16, G: 17, H: 18, I: 19, J: 20, K: 21, L: 22, M: 23, N: 24, O: 25).

The length of head was the most important discriminator, whereas the number of *ad* on hind tibia was the least (Table 17). Some basic data for the first 10 important measured variables were shown in Fig. 4.

Tests of significance between pairs of group centroids using the F-statistics were carried out

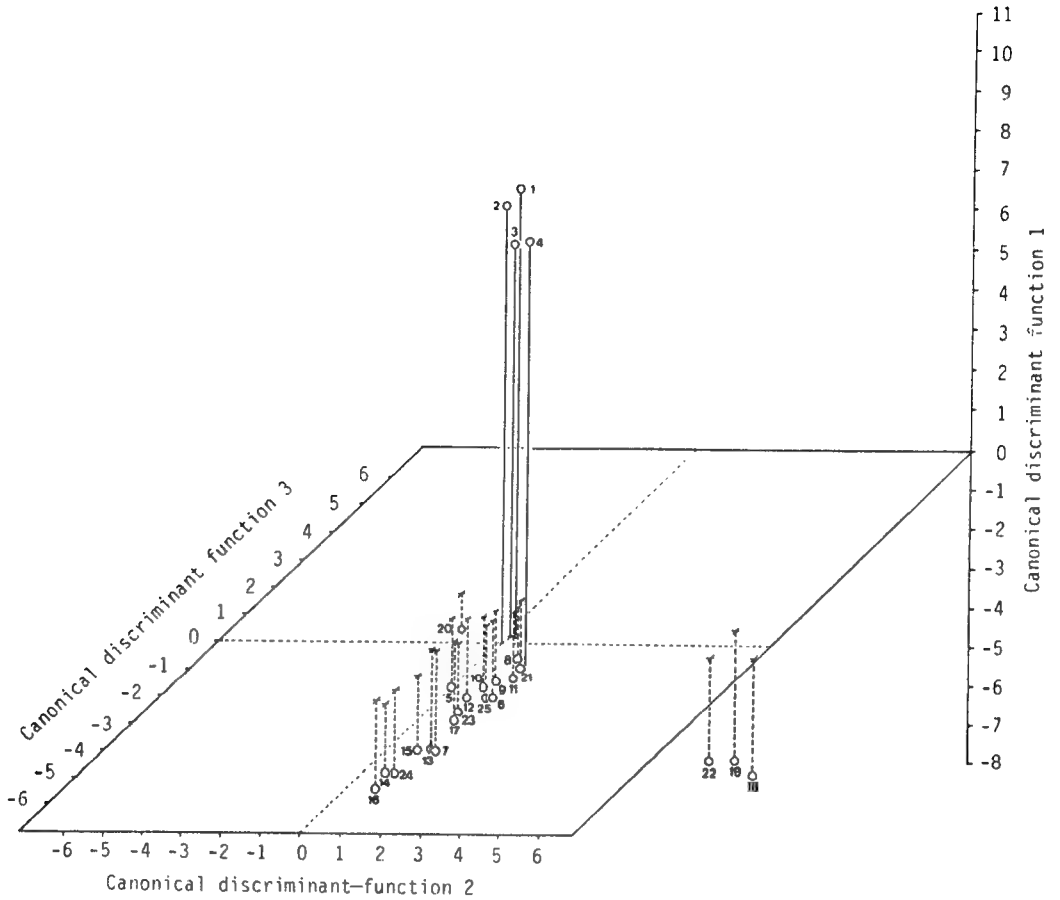

Fig. 12. 3-dimensional plot of the first 3 canonical discriminant functions by group centroids in females.

after step 27. Most are significantly different ($P<0.001$).

The predicted group membership made an average of 61.57% of individuals classified in their known group, and was slightly higher than in the case of males (Table 1). Groups 19 and 20 (both from Soraksan) had very high correct assignments at 90.0% and 95.0% respectively.

The interspecific morphological distinction, as a rule, is proved to be highly recognizable.

2-2. Analysis for interspecific level

2-2-1. Analysis using all characters

As in the analysis of males, the stacked histogram revealed 2 morphometrically distinct groups (Fig. 13).

All characters for discrimination of the 2 species were highly significant ($P<0.001$), among them the length of head was the most effective discriminator (Table 19).

The F-statistics and significances between pairs of groups after step 18 were also very significant ($P<0.001$).

In classification results, all 77 individuals of *D. antiqua and* all 420 individuals of *D. platura* were correctly classified in their known species group respectively (Table 20).

Table 17. Test for univariate equality of group means for 25 groups regardless of species in femle

Variable	Wilks' Lambda	F	Sign	Variable	Wilks' Lambda	F	Sign.
HW	.30621	45.32	.0000	T2	.34258	37.74	.0000
HL	.10115	174.8	.0000	M2	.58454	13.98	.0000
HH	.19227	82.62	.0000	AS	.30754	44.28	.0000
FW	.28499	49.34	.0000	DS	.87528	2.802	.0000
FL	.58244	14.10	.0000	F3	.33442	39.14	.0000
AW	.76620	6.001	.0000	T3	.27729	51.26	.0000
AL	.82617	4.138	.0000	M3	.56433	15.18	.0000
MW	.24421	60.87	.0000	AD	.89761	2.243	.0007
ML	.22479	67.82	.0000	PD	.89375	2.338	.0004
SW	.33064	39.81	.0000	AV	.67071	9.655	.0000
SL	.24603	60.27	.0000	PV	.62156	11.97	.0000
F1	.47469	21.76	.0000	WW	.40414	29.00	.0000
T1	.36429	34.32	.0000	WL	.38245	31.76	.0000
M1	.45615	23.45	.0000	RM	.42986	26.08	.0000
PS	.44682	24.35	.0000	MM	.69721	8.541	.0000
F2	.45756	23.31	.0000	WA	.26716	53.95	.0000

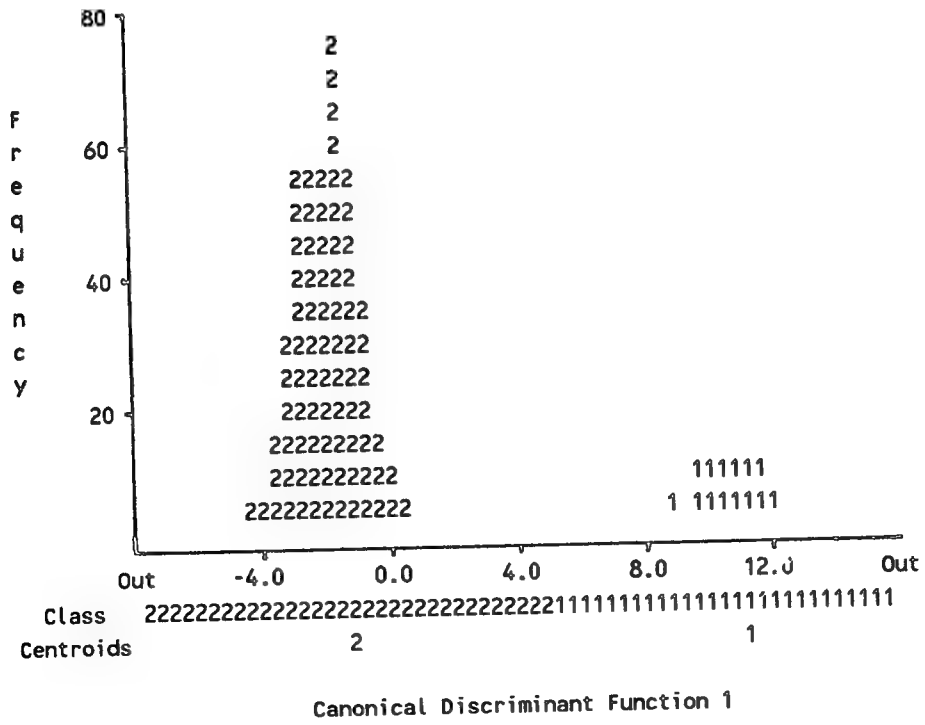

Fig. 13. All-groups stacked histogram of canonical discriminant function 1 against function 2 for morphometric analysis of species using all characters in female (group numbers as in Table 1).

Table 18. Predicted group membership for 25 groups regardless of species in female

Actual Group (Locality)	No.of Cases	Predicted Group Membership																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1 *antiqua*	20	14	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Kanghwado)		70.0%	10.0%	20.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
2 *antiqua*	20	1	15	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Tanyang)		5.0%	75.0%	5.0%	15.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
3 *antiqua*	17	0	2	14	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Uisong)		.0%	11.8%	82.4%	5.9%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
4 *antiqua*	20	0	1	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(Sillyong)		.0%	5.0%	.0%	95.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%
5 *platura*	20	0	0	0	0	12	1	0	0	0	0	0	0	0	1	1	0	1	0	0	2	0	0	0	2	0
(Kanghwado)		.0%	.0%	.0%	.0%	60.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	5.0%	.0%	.0%	10.0%	.0%	.0%	.0%	10.0%	.0%
6 *platura*	20	0	0	0	0	0	13	0	1	0	1	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0
(Tanyang)		.0%	.0%	.0%	.0%	.0%	65.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	.0%
7 *platura*	20	0	0	0	0	2	0	6	0	1	0	1	0	0	2	0	1	1	0	0	1	2	0	2	1	0
(Uisong)		.0%	.0%	.0%	.0%	10.0%	.0%	30.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	10.0%	.0%	5.0%	5.0%	.0%	.0%	5.0%	10.0%	.0%	10.0%	5.0%	.0%
8 *platura*	20	0	0	0	0	0	0	1	10	2	0	2	0	1	0	0	0	0	0	0	0	2	0	0	0	2
(Sillyong)		.0%	.0%	.0%	.0%	.0%	.0%	5.0%	50.0%	10.0%	.0%	10.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%	.0%	.0%	.0%	10.0%
9 *platura*	20	0	0	0	0	0	1	0	1	10	0	2	0	0	0	0	0	0	0	0	3	0	0	1	0	2
(Sillyong)		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	50.0%	.0%	10.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	15.0%	.0%	.0%	5.0%	.0%	10.0%
10 *platura*	20	0	0	0	0	0	3	0	0	2	10	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3
(Chongju)		.0%	.0%	.0%	.0%	.0%	15.0%	.0%	.0%	10.0%	50.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	15.0%
11 *platura*	20	0	0	0	0	0	1	0	2	1	1	8	1	1	0	0	0	2	0	0	0	0	2	0	1	
(Wando)		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	10.0%	5.0%	5.0%	40.0%	5.0%	5.0%	.0%	.0%	.0%	10.0%	.0%	.0%	.0%	.0%	.0%	10.0%	.0%	5.0%
12 *platura*	20	0	0	0	0	0	0	0	1	0	0	1	9	1	1	0	0	1	0	0	2	2	0	0	0	2
(Cheju)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	45.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	10.0%	10.0%	.0%	.0%	.0%	10.0%
13 *platura*	20	0	0	0	0	0	1	4	0	0	0	0	2	10	0	0	0	0	0	0	0	1	0	0	2	0
(Sillyong)		.0%	.0%	.0%	.0%	.0%	5.0%	20.0%	.0%	.0%	.0%	.0%	10.0%	50.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	10.0%	.0%
14 *platura*	20	0	0	0	0	3	0	0	0	0	0	0	0	0	13	0	1	0	0	0	0	0	0	0	2	1
(Taegu)		.0%	.0%	.0%	.0%	15.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	65.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%	5.0%
15 *platura*	20	0	0	0	0	1	0	1	0	1	0	0	0	1	2	10	0	0	0	0	1	0	0	2	1	0
(Taegu)		.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	5.0%	10.0%	50.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	0.0%	5.0%	.0%
16 *platura*	20	0	0	0	0	0	0	0	0	0	1	0	0	1	0	2	13	1	0	0	0	0	0	2	0	0
(Uijongbu)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	10.0%	65.0%	5.0%	.0%	.0%	.0%	.0%	.0%	10.0%	.0%	.0%
17 *platura*	20	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0	0	11	0	0	0	1	0	1	0	2
(Sillyong)		.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	10.0%	5.0%	.0%	.0%	.0%	.0%	55.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	10.0%
18 *platura*	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	3	0	0	2	0	0	0
(Taegu)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	75.0%	15.0%	.0%	.0%	10.0%	.0%	.0%	.0%
19 *platura*	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	2	0	0	0
(Soraksan)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	90.0%	.0%	.0%	10.0%	.0%	.0%	.0%
20 *platura*	20	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	19	0	0	0	0	0
(Soraksan)		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	95.0%	.0%	.0%	.0%	.0%	.0%
21 *platura*	20	0	0	0	0	0	0	1	0	3	1	2	0	0	0	0	0	0	0	0	1	10	0	2	0	0
(Kyerongsan)		.0%	.0%	.0%	.0%	.0%	.0%	4.0%	.0%	15.0%	5.0%	10.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	50.0%	.0%	10.0%	.0%	.0%
22 *platura*	20	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	4	2	0	0	12	0	0	0
(Ullungdo)		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	20.0%	10.0%	.0%	.0%	60.0%	.0%	.0%	.0%
23 *platura*	20	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0	1	0	12	0	2
(P'algongsan)		.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	60.0%	.0%	10.0%
24 *platura*	20	0	0	0	0	0	0	1	0	0	0	0	0	1	1	2	2	0	0	0	0	0	0	1	12	0
(Chirisan)		.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	10.0%	10.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	60.0%	.0%
25 *platura*	20	0	0	0	0	0	1	0	2	1	0	0	1	1	0	0	1	1	0	0	0	1	0	0	0	11
(Kumjongsan)		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	10.0%	5.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	55.0%

Percent "grouped" cases correctly classified : 61.57%

Table 19. Tests for univariate equality of group means for different species using all characters in female

Variable	Wilks' Lambda	F	Sign	Variable	Wilks' Lambda	F	Sign.
HW	.39185	768.2	.0000	T2	.73965	174.2	.0000
HL	.12074	3605.	.0000	M2	.67769	235.4	.0000
HH	.22698	1686.	.0000	AS	.32541	1026.	.0000
FW	.34819	926.6	.0000	DS	.96155	19.79	.0000
FL	.78620	134.6	.0000	F3	.44892	607.6	.0000
AW	.84780	88.86	.0000	T3	.82722	103.4	.0000
AL	.95505	23.30	.0000	M3	.62749	293.9	.0000
MW	.30679	1118.	.0000	AD	.95051	25.78	.0000
ML	.28107	1266.	.0000	PD	.93788	32.79	.0000
SW	.45002	605.0	.0000	AV	.70126	210.9	.0000
SL	.23500	1028.	.0000	PV	.66345	251.1	.0000
F1	.58100	357.0	.0000	WW	.50413	486.9	.0000
T1	.78492	135.6	.0000	WL	.46601	567.2	.0000
M1	.51593	464.4	.0000	RM	.47505	547.0	.0000
PS	.68404	228.6	.0000	MM	.79982	123.9	.0000
F2	.54864	407.2	.0000	WA	.33070	1002.	.0000

Table 20. Predicted group membership for different species using all characters in female

Actual Group (Species)	No.of Cases	Predicted Group Membership 1	2
1 *antiqua*	77	77	0
		100.0%	.0%
2 *platura*	420	0	420
		.0%	100.0%

Percent of "grouped" cases correctly classified: 100.00%

Table 21. Tests for univariate equality of group means for different species using measured characters only in female

Variable	Wilks' Lambda	F	Sign	Variable	Wilks' Lambda	F	Sign.
HW	.36185	768.2	.0000	M1	.51593	464.4	.0000
HL	.12074	3605.	.0000	F2	.54864	407.2	.0000
HH	.22698	1686.	.0000	T2	.73965	174.2	.0000
FW	.34819	926.6	.0000	M2	.67769	235.4	.0000
FL	.78620	134.6	.0000	F3	.44892	607.6	.0000
AW	.84780	88.86	.0000	T3	.82722	103.4	.0000
AL	.95505	23.30	.0000	M3	.62749	293.9	.0000
MW	.30679	1118.	.0000	WW	.50413	486.9	.0000
ML	.28107	1266.	.0000	WL	.46601	567.2	.0000
SW	.45002	605.0	.0000	RM	.47505	547.0	.0000
SL	.32500	1028.	.0000	MM	.79982	123.92	.0000
F1	.58100	357.0	.0000	WA	.33070	1002.	.0000
T1	.78492	135.6	.0000				

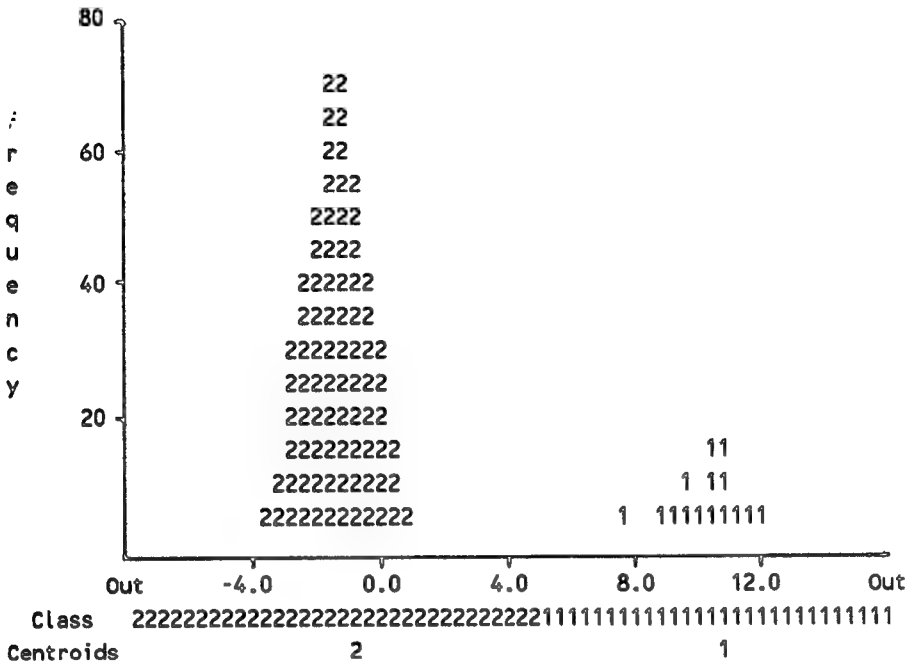

Fig. 14. All-groups stacked histogram of canonical discriminant function 1 against function 2 for morphometric analysis of species using measured characters only in female (group numbers as in Table 1).

2-2-2. Analysis excluding meristic characters

As in previous analysis, the interspecific discrimination was shown by the stacked histogram which revealed 2 morphometrically distinct groups (Fig. 4).

All characters for discriminating the 2 species were highly significant ($P<0.001$), and the most powerful discriminator was also the length of head as in the case of the analysis using all characters (Table 21).

After step 11, the F-statistics and significance between 2 species were very significant ($P<0.001$).

In the classification results, each species group revealed 100% successful classification (Table 22).

Table 22. Predicted group membership for different species using measured characters only in female

Actual Group (Species)	No.of Cases	Predicted Group Membership 1	2
1 *antiqua*	77	77	0
		100.0%	.0%
2 *platura*	420	0	420
		.0%	100.0%

Percent of "grouped" cases correctly classified: 100.0%

2-3. Analysis for intraspecific level

2-3-1. Analysis for *Delia antiqua*

2-3-1-1. Analysis of different populations

All the 3 canonical discriminant functions resulted in the analysis were statistically very significant. Only functions 1 and 2 which had an accumulative variance of 78.68% were used in the all groups scatterplot (Fig. 15).

Most characters were not significant to the intraspecific discrimination ($P>0.001$), but the area of wing was the most powerful discriminator (Table 23).

Tests of significance between pairs of group centroids using the F-statistics were done after step 20. All the groups are very significantly different ($P<0.001$). Only groups 1 (from Kanghwado) and 3 (from Üisŏng) were less significant.

As for the predicted group membership, group 4 (from Sillyŏng) revealed 100% successful classification, but the other groups slightly overlapped between the populations (Table 24). Overall, 89.61% of all individuals were correctly assigned to their known species. Thus, the female population was more correctly classified than the male.

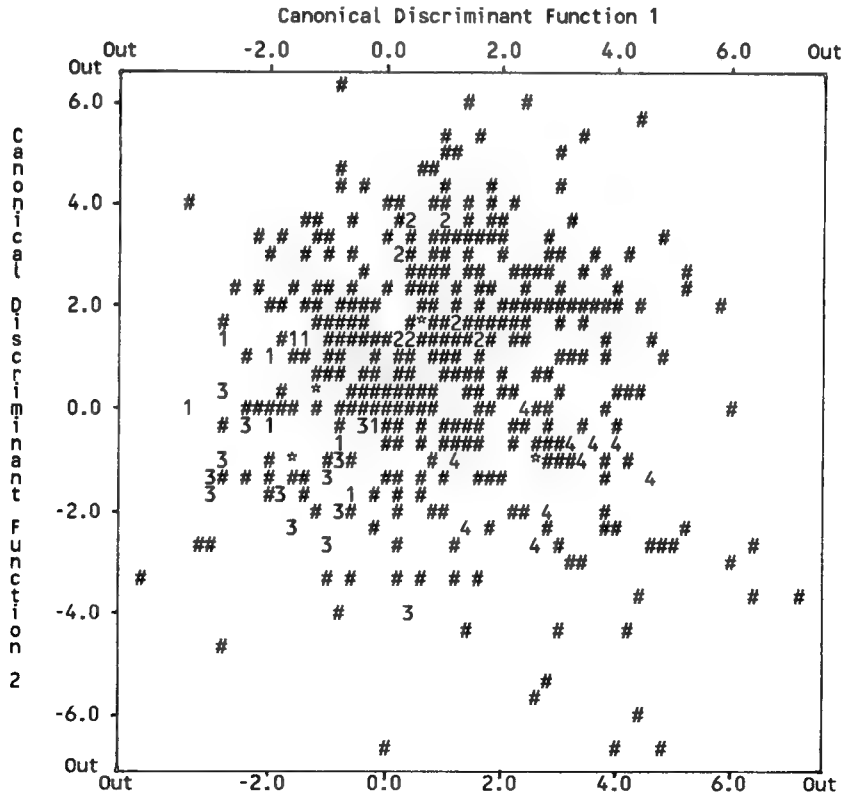

Fig. 15. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of different populations of *Delia antiqua* in female (group numbers as in Table 1, except for, #: ungrouped cases).

Table 23. Tests for univariate equality of group means for different populations of *Delia antiqua* in female

Variable	Wilks' Lambda	F	Sign	Variable	Wilks' Lambda	F	Sign.
HW	.89464	2.866	.0424	T2	.95936	1.031	.3841
HL	.94778	1.341	.2678	M2	.78933	6.495	.0006
HH	.95619	1.115	.3487	AS	.98761	.3053	.8215
FW	.93848	1.595	.1979	DS	.95383	1.178	.3241
FL	.92773	1.895	.1379	F3	.84252	4.548	.0056
AW	.93087	1.807	.1534	T3	.81638	5.473	.0019
AL	.98501	.3703	.7746	M3	.81720	5.443	.0020
MW	.84305	4.530	.0057	AD	.90729	2.487	.0672
ML	.91071	2.386	.0760	PD	.96156	.9727	.4104
SW	.85357	4.174	.0087	AV	.97282	.6799	.5672
SL	.92066	2.097	.1080	PV	.93947	1.568	.2045
F1	.94509	1.414	.2456	WW	.79196	6.392	.0007
T1	.99412	1.439	.9333	WL	.87709	3.410	.0219
M1	.93962	1.564	.2055	RM	.94669	1.370	.2586
PS	.86829	3.691	.0156	MM	.90627	2.517	.0648
F2	.95748	1.080	.3628	WA	.77732	6.971	.0003

Table 24. Predicted group membership for different populations of *Delia antiqua* in female

Actual Group (Species)	No.of Cases	Predicted Group Membership 26	27	28	29
1 Kanghwado	20	17	3	0	0
		85.0%	15.0%	.0%	.0%
2 Tanyang	20	0	17	2	1
		.0%	85.0%	10.0%	5.0%
3 Uisong	17	1	1	15	0
		5.9%	5.9%	88.2%	.0%
4 Sillyong	20	0	0	0	20
		.0%	.0%	.0%	100.0%
Ungrouped Cases	420	1	270	92	57
		.2%	64.3%	21.9%	13.6%

Percent of "grouped" cases correctly classified: 89.61%

2-3-1-2. Analysis for different host

The stacked histogram showed a slight overlap between the groups obtained from garlics and spring onions (Fig. 16).

Most characters were insignificant for discrimination of groups ($P>0.001$), whereas the lengths of mid metatarsus, hind metatarsus, and the width of mesonotum were significant (Table 25).

The F-statistics and significances between 2 groups after step 17 were very significant ($P<0.001$), and the most powerful discriminator was the length of mid metatarsus, which was first entered into the analysis, on the other hand the length of mid tibia was last entered.

In the predicted group membership, group 1 (from garlics) was 93.0% correctly classified, with 7.0% (4 individuals) classified as group 2 (from spring onions), which revealed 100% successful

classification. Overall, 94.81% of all individuals were correctly assigned to their known group, and the figure was higher than in the previous analysis (Table 26).

Thus, it seemed that morphological variations of this species were more effected by its hosts than by its distribution areas.

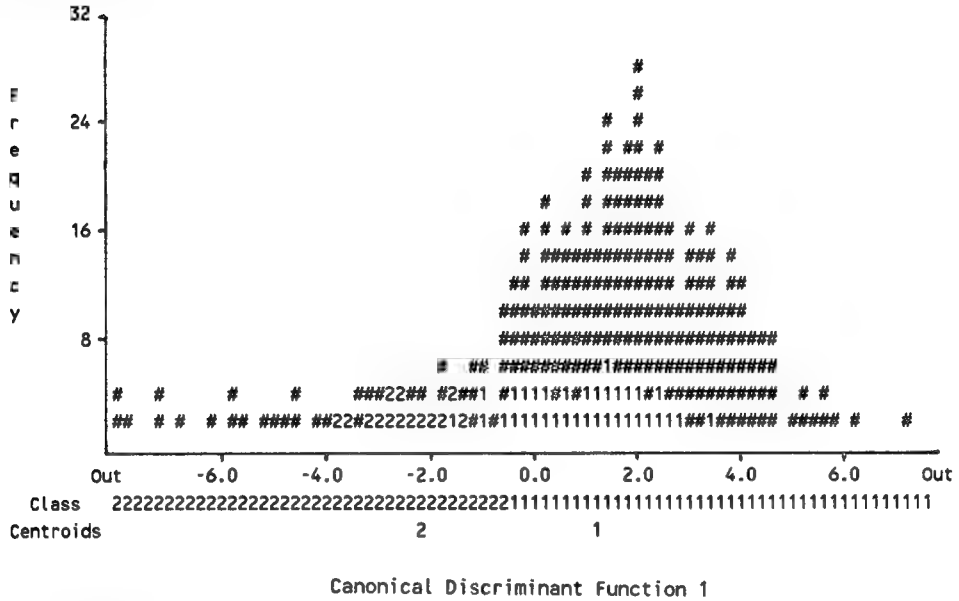

Fig. 16. All-groups stacked histogram of canonical discriminant function 1 against function 2 for morphometric analysis of different host populations of *Delia antiqua* in female (group numbers as in Table 1, except for, #: Ungrouped cases).

Table 25. Tests for univariate equality of group means by different host populations of *Delia antiqua* in female

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.94745	4.160	.0449	T2	.96638	2.609	.1105
HL	.95548	3.494	.0655	M2	.80065	18.67	.0000
HH	.99369	.4556	.5017	AS	.99847	.1146	.7359
FW	.98303	1.295	.2588	DS	.98578	1.082	.3015
FL	.95605	3.448	.0673	F3	.95016	3.934	.0510
AW	.98627	1.044	.3101	T3	.86656	11.55	.0011
AL	.99972	.20E-01	.8859	M3	.84328	13.94	.0004
MW	.84859	13.38	.0005	AD	.92252	6.299	0.142
ML	.93317	5.371	0.232	PD	.99884	.87E-01	.7684
SW	.88602	9.648	.0027	AV	1.00000	.29E-03	.9863
SL	.97020	2.304	.1333	PV	.96131	3.019	.0864
F1	.96533	2.694	.1049	WW	.94975	3.968	.0500
T1	.99480	.3919	.5332	WL	.90637	7.747	.0068
M1	.93997	4.790	.0317	RM	.99721	.2100	.6481
PS	.99401	.4518	.5035	MM	.99663	.2533	.6162
F2	.99941	.44E-01	.8336	WA	.87415	10.80	.0015

Table 26. Predicted group membership by different host populations of *Delia antiqua* in female

Actual Group (Species)	No.of Cases	Predicted Group Membership 1	2
1 Garlic	57	53	4
		93.0%	7.0%
2 Spring Onion	20	0	20
		.0%	100.0%
Ungrouped	420	364	56
Cases		86.7%	13.3%

Percent of "grouped" cases correctly classified: 94.81%

2-3-2. Analysis for *Delia platura*

2-3-2-1. Analysis of different populations

On 20 discriminant functions derived in the analysis, only the first 2 functions having an accumulative variance of 71.81% were used in the all groups scatterplot which revealed 2 separate groups: the smaller group consisted of populations 18 (from Taegu), 19 (from Sŏraksan), and 22 (from Ullŭn gdo); the larger group with the other populations (Fig. 17).

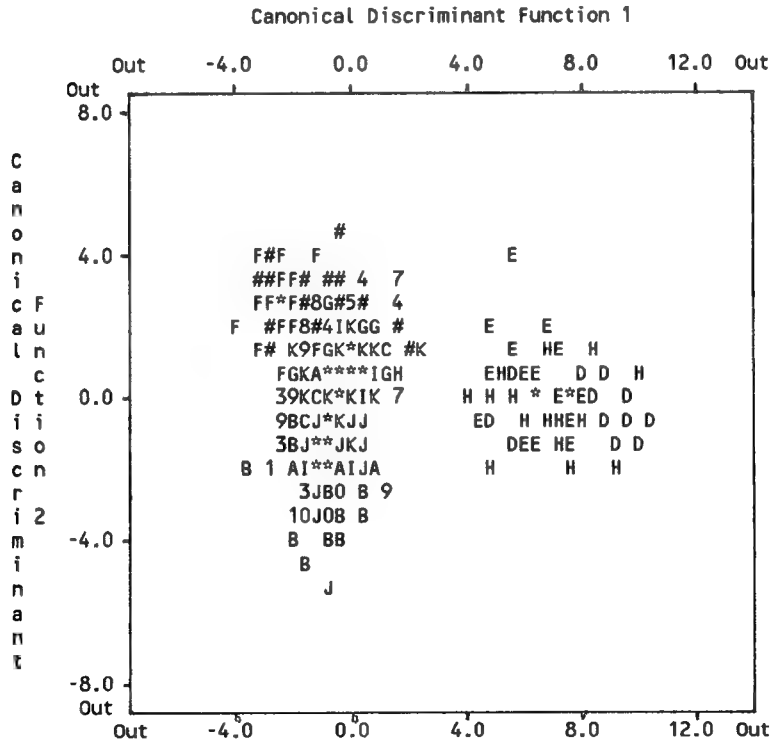

Fig. 17. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of different populations of *Delia platura* in famale (group numbers indicated as 1:5, 2:6, 3:7, 4:8, 5:9, 6:10, 7:11, 8:12, 9:13, 0:14, A:15, B:16, C:17, D:18, E:19, F:20, G:21, H:22, I:23, J:24, K:25, #: ungrouped cases).

Table 27. Tests for univariate equality of group means for different populations of *Delia antiqua* in female

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.75540	6.460	.0000	T2	.44101	25.29	.0000
HL	.81818	4.433	.0000	M2	.87235	2.919	.0000
HH	.83117	4.052	.0000	AS	.94006	1.272	.1934
FW	.79063	5.283	.0000	DS	.90880	2.002	.0067
FL	.72076	7.729	.0000	F3	.73051	7.360	.0000
AW	.89775	2.272	.0015	T3	.31104	44.19	.0000
AL	.84873	3.556	.0000	M3	.90868	2.005	.0065
MW	.78717	5.394	.0000	AD	.95216	1.002	.4582
ML	.78131	5.584	.0000	PD	.94731	1.110	.3362
SW	.71440	7.976	.0000	AV	.95109	1.026	.4298
SL	.73092	7.344	.0000	PV	.93078	1.484	.0828
F1	.79729	5.072	.0000	WW	.80395	4.865	.0000
T1	.42365	27.14	.0000	WL	.81128	4.641	.0000
M1	.87641	2.813	.0001	RM	.89514	2.337	.0010
PS	.54929	16.37	.0000	MM	.86389	3.143	.0000
F2	.82169	4.329	.0000	WA	.81675	4.476	.0000

Most of the measured characters were very significant ($P<0.001$), but meristic characters were not (Table 27). Of them, the length of hind tibia was the most effective discriminator.

Tests of significance between pairs of group centroids using the F-statistics were done after step 27. Many pairs of groups were remarkably different ($P<0.001$), but some were not.

In the predicted group membership, groups 19 and 20 (both from Sŏraksan) had high correct assignment at 90% and 95% respectively, but most populations were much lower (Table 28). Overall, 58.10% of all individuals were correctly assigned to their known group, and the precentage is higher than that of the analysis in the males.

Therefore, it seemed that intraspecific morphological differences were not significant morphometrically. But groups 19 and 20 (both from Sŏraksan) and needed to revise again substantially.

2 3-2-2. Analysis for different host

As in the male, 3 discriminant functions were derived. The first 2 functions were highly significant with an accumulative variance of 82.42%, and were used for the all groups scatterplot (Fig. 18).

As in the previous analysis, the most effective discriminator was the length of hind tibia (Table 29).

The F-statistics and significances between pairs of groups after step 24 were remarkable significant ($P<0.001$), and the length of hind tibia was the most powerful contributor.

The predicted group membership made an average of 55.71% of all individuals classified in their known group, and the figure was slightly lower than that of the analysis of the different local populations (Table 30).

Thus, as in the previous analysis, the interspecific variation for hosts were not recognized.

Table 28. Predicted group membership for different populations of *Delia platura* in female

Actual Group (Locality)	No.of Cases	Predicted Group Membership																					
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
5 Kanghwado	20	12	1	1	0	0	0	0	0	0	1	1	0	0	0	0	2	0	0	0	2	0
		60.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	10.0%	.0%	.0%	.0%	10.0%	.0%
6 Tanyang	20	0	13	0	1	0	1	0	0	1	0	1	0	1	0	0	0	0	0	1	0	1
		.0%	65.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	5.0%
7 Ŭisŏng	20	2	0	6	0	2	1	1	0	0	2	1	1	0	0	0	1	1	0	1	1	0
		10.0%	.0%	30.0%	.0%	10.0%	5.0%	5.0%	.0%	.0%	10.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	5.0%	5.0%	.0%
8 Sillyŏng	20	0	0	0	10	2	0	2	0	1	0	0	0	0	0	0	1	3	0	0	0	1
		.0%	.0%	.0%	50.0%	10.0%	.0%	10.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	15.0%	.0%	.0%	.0%	5.0%
9 Sillyŏng	20	0	1	0	1	10	0	2	0	0	0	0	0	0	0	0	3	0	0	1	0	2
		.0%	5.0%	.0%	5.0%	50.0%	.0%	10.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	15.0%	.0%	.0%	5.0%	.0%	10.0%
10 Chŏngju	20	0	3	0	0	2	11	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
		.0%	15.0%	.0%	.0%	10.0%	55.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%
11 Wando	20	0	0	0	1	3	1	7	1	1	0	0	0	2	0	0	0	0	0	2	0	2
		.0%	.0%	.0%	5.0%	15.0%	5.0%	35.0%	5.0%	5.0%	.0%	.0%	.0%	10.0%	.0%	.0%	.0%	.0%	.0%	10.0%	.0%	10.0%
12 Cheju	20	0	0	0	1	0	0	0	9	1	1	0	0	1	0	0	2	2	0	0	0	3
		.0%	.0%	.0%	5.0%	.0%	.0%	.0%	45.0%	5.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	10.0%	10.0%	.0%	.0%	.0%	15.0%
13 Sillyŏng	20	0	2	3	0	0	0	0	1	10	0	0	0	0	0	0	1	1	0	0	2	0
		.0%	10.0%	15.0%	.0%	.0%	.0%	.0%	5.0%	50.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	10.0%	.0%
14 Taegu	20	3	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	2	1
		15.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	70.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%	5.0%
15 Taegu	20	1	0	1	0	1	0	0	0	0	2	10	0	0	0	0	1	0	0	3	1	0
		5.0%	.0%	5.0%	.0%	5.0%	.0%	.0%	.0%	.0%	10.0%	50.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	15.0%	5.0%	.0%
16 Ŭijŏngbu	20	0	0	0	0	0	1	0	0	1	0	2	13	1	0	0	0	0	0	2	0	0
		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	10.0%	65.0%	5.0%	.0%	.0%	.0%	.0%	.0%	10.0%	.0%	.0%
17 Sillyŏng	20	0	0	1	0	0	1	2	0	0	0	0	0	11	0	0	0	1	0	1	0	3
		.0%	.0%	5.0%	.0%	.0%	5.0%	10.0%	.0%	.0%	.0%	.0%	.0%	55.0%	.0%	.0%	.0%	5.0%	.0%	5.0%	.0%	15.0%
18 Taegu	20	0	0	0	0	0	0	0	0	0	0	0	0	0	15	3	0	0	2	0	0	0
		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	75.0%	15.0%	.0%	.0%	10.0%.	.0%	.0%	.0%
19 Sŏraksan	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	2	0	0	0
		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	90.0%	.0%	.0%	10.0%.	0%	.0%	.0%
20 Sŏraksan	20	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	19	0	0	0	0	0
		.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	95.0%	.0%	.0%	.0%	.0%	.0%
21 Kyerongsan	20	0	0	0	0	4	1	1	0	0	0	0	0	0	0	0	2	10	0	2	0	0
		.0%	.0%	.0%	.0%	20.0%	5.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	10.0%	50.0%	.0%	10.0%	.0%	.0%
22 Ŭllŭngdo	20	0	0	0	0	0	1	0	0	0	0	0	0	0	4	2	0	1	12	0	0	0
		.0%	.0%	.0%	.0%	.0%	5.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	20.0%	10.0%	.0%	5.0%	60.0%	.0%	.0%	.0%
23 P'algongsan	20	0	1	1	0	0	0	1	1	0	0	1	1	1	0	0	0	1	0	11	0	1
		.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	5.0%	.0%	.0%	5.0%	5.0%	5.0%	.0%	.0%	.0%	5.0%	.0%	55.0%	.0%	5.0%
24 Chirisan	20	0	0	1	0	0	1	0	0	0	1	2	2	0	0	0	0	0	0	1	12	0
		.0%	.0%	5.0%	.0%	.0%	5.0%	.0%	.0%	.0%	5.0%	10.0%	10.0%	.0%	.0%	.0%	.0%	.0%	.0%	.0%	5.0%	60.0%	.0%
25 Kŭmjŏngsan	20	0	0	0	2	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	1	11
		.0%	.0%	.0%	10.0%	5.0%	.0%	.0%	5.0%	5.0%	5.0%	.0%	5.0%	.0%.	.0%	.0%	.0%	5.0%	.0%	.0%	5.0%	55.0%
Ungrouped Cases	77	0	0	0	27	0	3	5	0	0	2	0	0	0	0	0	39	0	0	1	0	0
		.0%	.0%	.0%	35.1%	.0%	3.9%	6.5%	.0%	.0%	2.6%	.0%	.0%	.0%	.0%	.0%	50.6%	.0%	.0%	1.3%	.0%	.0%

Percent of "grouped"cases correctly classified : 58.10%

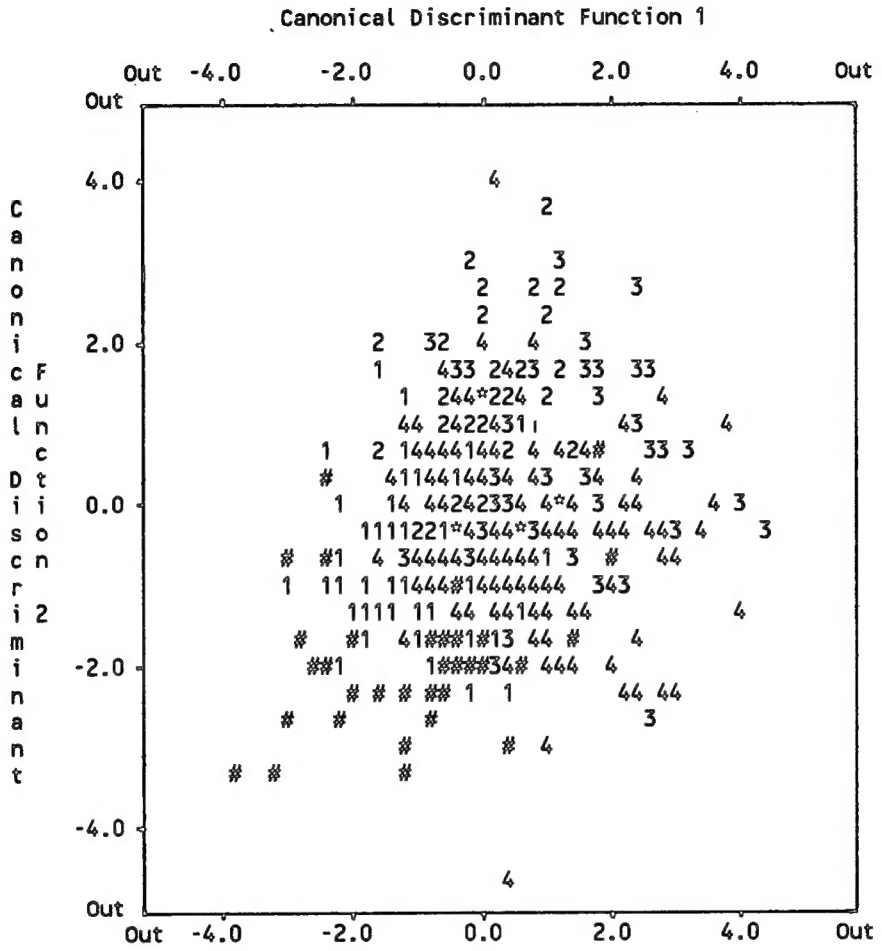

Fig. 18. All-groups scatterplot of canonical discriminant function 1 against function 2 for morphometric analysis of different host populations of *Delia platura* in female (group numbers indicated as 1: 3, 2: 4, 3: 5, 4: 6, #: ungrouped cases).

3. Conclusion

Multivariate approaches based on the continuous quantitative characters confirmed the morphometric distinctions at interspecific level between the 2 species, *Delia antiqua* and *D. platura*. Whereas intraspecific variational ranges in both species, were mostly not significant.

In the analysis conducted between all groups both within and between species, the average group membership for male and female populations revealed 55.94% and 61.57% correct assignment respectively. For interspecific comparision, all individuals in both sexes were 100% successfully classified to their known species.

When intraspecific variations of the both sexes of *antiqua* were compared, the correct assignments for the populations were averaged at 77.92% in males, and 89.61% in females, whereas

Table 29. Tests for univariate equality of group means by different host populations of *Delia platura* in female

Variable	Wilks' Lambda	F	Sign.	Variable	Wilks' Lambda	F	Sign.
HW	.99313	.9597	.4117	T2	.92166	11.79	.0000
HL	.98243	2.479	.0607	M2	.96262	5.385	.0012
HH	.97370	3.746	.0112	AS	.99713	.3997	.7533
FW	.99279	1.007	.3896	DS	.98498	2.114	.0978
FL	.96841	4.524	.0039	F3	.93955	8.921	.0000
AW	.98231	2.497	.0593	T3	.90629	14.34	.0000
AL	.99091	1.273	.2833	M3	.97708	3.252	.0217
MW	.98425	2.219	.0853	AD	.99325	.9420	.4202
ML	.98514	2.092	.1006	PD	.99706	.4094	.7464
SW	.92486	11.27	.0000	AV	.99308	.9668	.4083
SL	.97927	2.936	.0332	PV	.98062	2.740	.0430
F1	.96676	4.767	.0028	WW	.96926	4.398	.0046
T1	.92957	10.51	.0000	WL	.98495	2.118	.0973
M1	.95752	6.151	.0004	RM	.99109	1.247	.2922
PS	.98253	2.465	.0618	MM	.98180	2.570	.0538
F2	.95615	6.359	.0003	WA	.98596	1.975	.1171

Table 30. Predicted group membership by different host populations of *Delia platura* in female

Actual Group (Host)	No. of Cases	Predicted Group Membership 3	4	5	6
3 Garlic	160	93	30	11	26
		58.1%	18.8%	6.9%	16.3%
4 Onion	60	7	43	4	6
		11.7%	71.7%	6.7%	10.0%
5 Spring Onion	60	10	6	35	9
		16.7%	10.0%	5.3%	15.0%
6 Wild	140	29	21	27	63
		20.7%	15.0%	19.3%	45.0%
Ungrouped	77	21	2	0	54
Cases		27.3%	2.6%	.0%	70.1%

Percent of "grouped" cases correctly classified: 55.71%

those for hosts were averaged at 92.21% and 94.81% respectively. Thus, the intraspecific variational ranges were proved to be slightly significant although some groups overlapped partly among them.

On the other hand, in the analysis of male and female *platura*, 54.29% and 58.10% for different local populations were correctly classified respectively, while 50.71% and 55.71% for hosts were correctly assigned. Therefore, in this species the intraspecific morphological variations were not recognized significantly.

As a rule, the intraspecific differences of female populations were slightly higher than those of males.

The predicted group membership of reared populations was slightly higher than those of collected populations on field.

The intraspecific morphological variations for occurrence times were detected as slightly significant.

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한국産 고자리꽃파리와 씨고자리꽃파리의 計量形態學的 多變量 分類 (파리目 : 꽃파리科)

徐 相 仁 · 權 容 正

慶北大學校 農科大學 農生物學科

고자리꽃파리 및 씨고자리꽃파리는 마늘, 양파 및 파 등 球根類 作物을 加害하는 중요한 農業害蟲이나, 그 형태적 類似性으로 인해 지금까지 學名適用에 있어서 학자간에 수많은 오류를 범하고 있다. 따라서 이들 2種에 대한 種間 및 各 種內의 地域別, 時期別, 寄主植物別 등에 따른 형태적 正量形質의 多變量 解析을 실시하였다. 그 결과, 兩種間에는 100%의 分離率로 명백히 구분되나, 2種 모두 地域別, 時期別 및 寄主植物別 등에 따른 種內 正量形質의 차이는 고자리꽃파리에서는 分離率이 모두 75% 이상으로 높았으며, 씨고자리꽃파리에서는 60% 이하로 낮게 나타났다.

검색어 : 計量形態學, 數理分類, 多變量分析, 判別分析, 파리目, 꽃파리科